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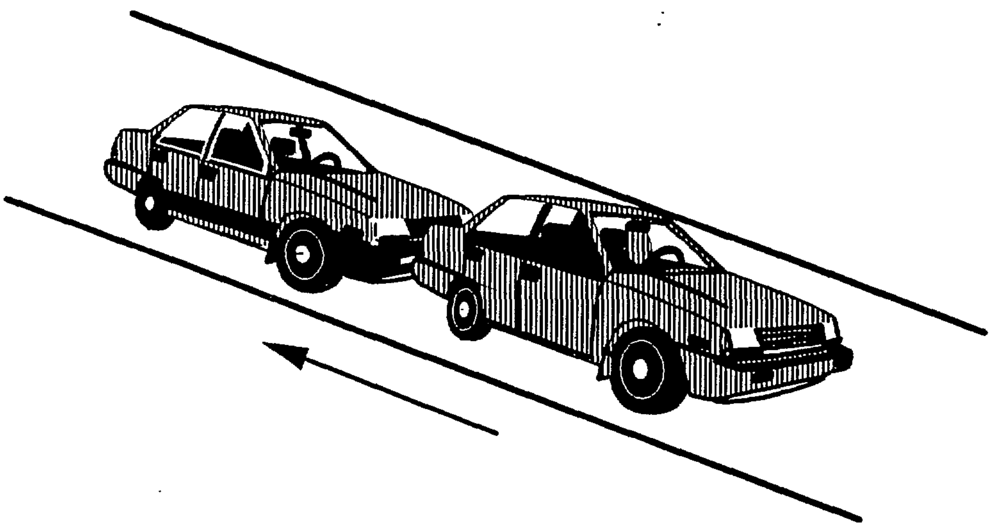
Backing Crashes: Problem Size Assessment and Statistical Description



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16. Abstract

This document presents problem size assessments and statistical crash descriptions for backing crashes and several key subtypes of backing crashes. Backing crashes are a potential "target crash" of high-technology Intelligent Vehicle Highway System (IVHS) crash avoidance countermeasures. To elucidate potential countermeasure applicability, backing crashes are divided into two types: encroachment and crossing-path backing crashes. The emphasis of this report is on the encroachment backing crashes, in particular encroachment crashes where the vehicle is under control. This subclass is likely to be most amendable to prevention by an obstacle detection system. Principal data sources are the 1990 General Estimates System (GES) and Fatal Accident Reporting System (FARS). The crash problem size is assessed using such measures as number of crashes, number and severity of injuries, number of fatalities, crash involvement rate, crash involvement likelihood. Problem size statistics are provided for four vehicle type categories: all vehicles, passenger vehicles (i.e., cars, light trucks, light vans), combination-unit trucks and medium/heavy single-unit trucks. Encroachment backing crashes are described statistically primarily in terms of the conditions under which they occur (e.g., time of day, weather, roadway type, relation to junction) and, when data are available, in terms of possible contributing factors.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

This document presents problem size assessments and statistical crash descriptions for backing crashes. Principal data sources are the 1990 General Estimates System (GES) and Fatal Accident Reporting System (FARS). Backing crashes are potential "target crashes" of high-technology Intelligent Vehicle Highway System (IVHS) crash avoidance countermeasures. For example, the proximity detection warning system concept (e.g., detection of obstacles in the rear blind zone through the use of radar, ultrasound, or similar technologies) has been suggested as a possible countermeasure applicable to this crash type.

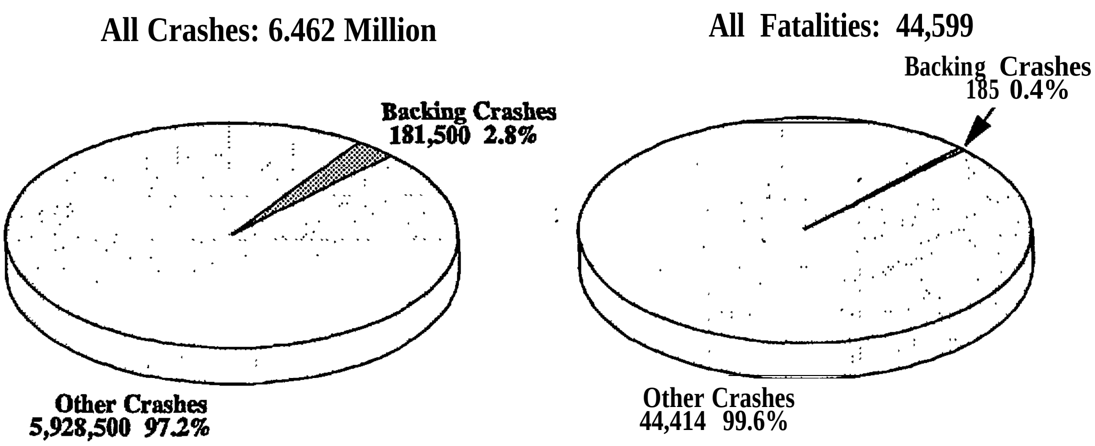
In this report, the backing crash problem size is assessed using such measures as number of crashes, number and severity of injuries, number of fatalities, crash involvement rate, and crash involvement likelihood. Problem size statistics are provided for four vehicle type categories: all vehicles combined, passenger vehicles (i.e., cars, light trucks, light vans), combination-unit trucks, and medium/heavy single-unit trucks.

Overall Problem Size

Principal statistical fmdings regarding the backing problem size include the following:

- In 1990, there were approximately 181,500 police-reported backing crashes with 185 associated fatalities. (Note, however, that these statistics based on police accident reports generally do not include off-roadway crashes such as driveway backing crashes.) **Figure ES-l** illustrates the backing crash and fatality statistics in relation to all crashes and fatalities.

Figure ES-l



- There were approximately 22,000 associated injuries, including 1,500 serious (incapacitating) injuries.

- Nevertheless, approximately 91 percent of 1990 backing crashes were property-damage-only.

- Backing crashes constituted about 3 percent of all police-reported crashes, but accounted for only about 0.4 percent of all fatalities.

- During its operational life, a vehicle can be expected to be involved in 0.01 police-reported (PR) backing crashes as the backing vehicle.

- The above statistics relate to police-reported crashes. This report presents a method for estimating annual ***non-police reported*** (NPR) backing crashes which yielded an estimate of approximately 300,000 for 1990. The accuracy of this estimate is problematic considering the apparently large number of backing crashes that occur off-roadway. In particular, there are a significant but unknown number of off-roadway pedestrian backing crashes, many of which involve young children.

- The report also presents a method for estimating crash-caused delay in vehicle-hours. Based on the estimation algorithm described in the report, backing crashes cause only about 1 percent of all crash-caused delay.

Backing Crash Type Taxonomy

Following the overall problem size assessment, this report disaggregates the overall problem into the following types and subtypes:

1. Slow-closing-speed ***encroachment*** backing crashes.

    a. ***Pedestrian/pedalcyclist.***

    b. ***Parallel path,*** struck vehicle; i.e. , backing vehicle strikes front of stationary or very slow-moving vehicle.

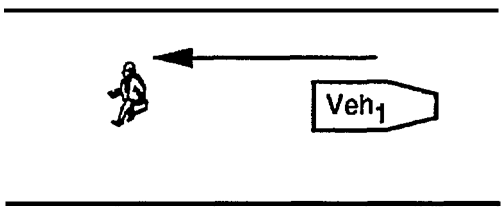
    c. ***Curved path,*** struck stationary vehicle or object; backing vehicle strikes side, comer, or back of other vehicle or strikes object. Such backing vehicles are usually following a curved path (i.e., turning) while backing out of driveway or parking space.

2. ***Crossing path*** backing crashes involving higher closing speeds.

Figure Es-2 (from Tijerina et al, 1993) illustrates the three encroachment subtypes and crossing-path subtype schematically. The principal rationale for the encroachment versus crossing-path dichotomy is potential countermeasure applicability. The encroachment-type backing crashes appear to be generally applicable to the proximity detection countermeasure concept, whereas the applicability of crossing path backing crashes to this countermeasure concept is questionable.

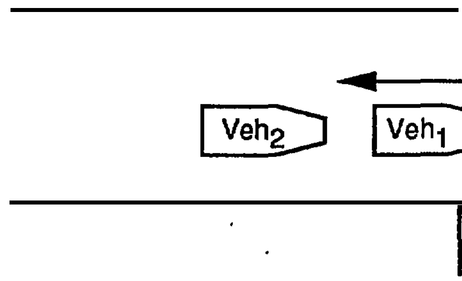
Figure ES-2
Backing Crash Types and Subtypes

Encroachment: Pedestrian/Pedalcyclist



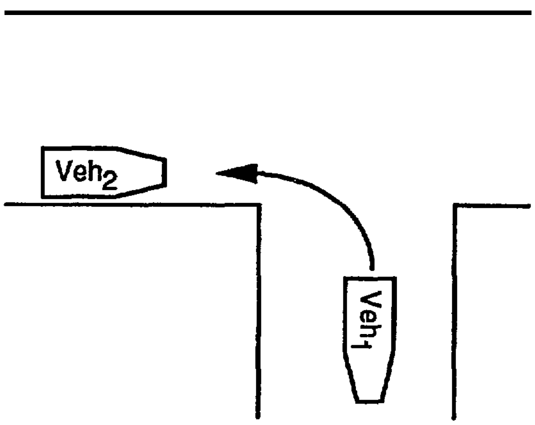
- Pedestrian or pedalcyclist behind Veh,
- Veh, backs & hits pedestrian or pedalcyclist

Encroachment: Parallel Path



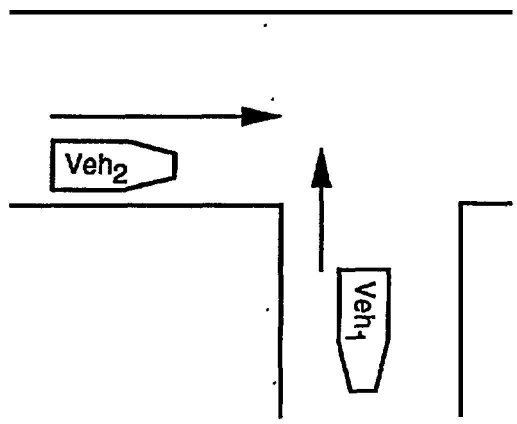
- Veh, & Veh, on roadway, traveling in same lane in same direction
- Veh, stops
- Veh, reverses direction & hits Veh,

Encroachment: Curved Path



- Veh, stationary
- Veh, backs into Veh,

Crossing Path



- Veh_2 traveling on roadway
- Veh, backs into Veh, or is struck by Veh_2

The descriptors "parallel path," "curved path," and "crossing-path" are intended to describe the ***predominant*** vehicle movements for these subtypes, but they are not themselves the basis of the data specifications since such descriptions of the pre-crash path (e.g., straight versus curved) are not contained in GES or FARS. The terms "parallel path, "curved path," and "crossing-path" arose from examinations of individual backing crash case files conducted by Tijerina et ***al*** (1993) as part of a related backing crash countermeasure assessment. The terms are used here in order to maintain consistency with that analysis.

Figure ES-3 shows the relative crash problem sizes of these crash types and subtypes.

Figure ES-3. Backing Crash Types and Subtypes

All Backing Crashes: 181,500

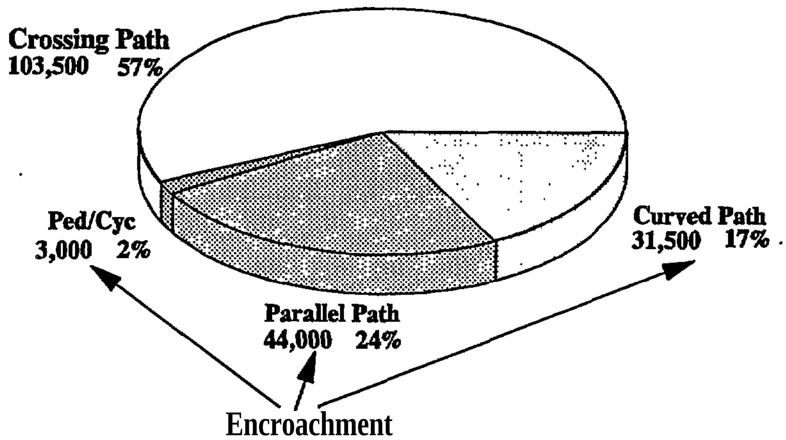


Figure ES-3 shows that of the estimated 181,500 backing crashes in 1990, 78,000 (43 percent) were encroachment-type and 103,500 (57 percent) were crossing-path type. Within the encroachment type:

- 3,000 (1.7 percent of all backing crashes) were pedestrian/pedalcyclist.

- 44,000 (24 percent of all backing crashes) were parallel path crashes into a vehicle (see section 2.2 for definition/explanation).

- 31,500 (17 percent of all backing crashes) were curved path crashes into a vehicle or object (see section 2.2 for definition/explanation).

FARS statistics show that, of the 185 backing crash traffic fatalities in 1990,:

- 73 (39 percent) occurred in crossing-path crashes

- 100 (54 percent) were pedestrians/pedalcyclists

- Only 1 (0.5 percent) occurred in a parallel path, struck vehicle crash.
- Only 11 (5.9 percent) occurred in curved path, struck vehicle/object crashes.

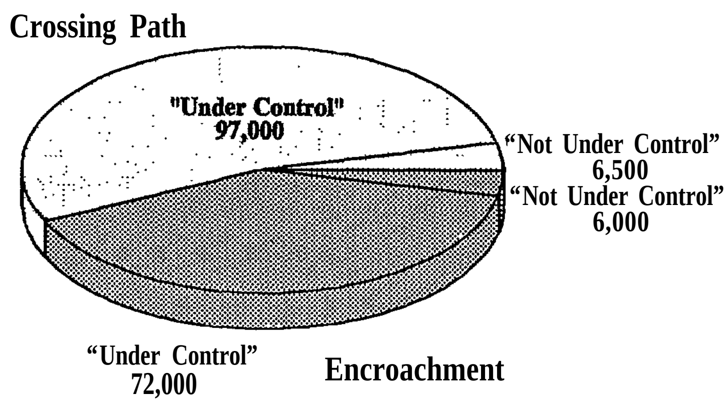
Studies of non traffic pedestrian backing crashes suggest that an additional 100 to 200 pedestrians are killed each year from non traffic/off-roadway backing crashes. Most of these are young children killed in driveways or parking lots.

"Under Control" Backing Crashes

As noted, the principal purpose of this statistical assessment was to identify potential target crashes for countermeasures. Emphasis was on the proximity detection warning system concept. Accordingly, additional "disqualifiers" were added to the target crash definitions to eliminate crashes where the backing vehicle was potentially ***not under control*** and thus the driver would not be capable of responding to a collision warning. Thus, for this variation of the problem size assessment, crashes involving icy/snowy roadway surfaces, selected vehicle defects, driverless vehicles, grossly-intoxicated drivers, and selected driver physical impairments were excluded from the problem sizes. For the encroachment backing crash type, the target crash definitions and problem size assessments were intended to capture crashes potentially amenable to prevention with rear-blind-zone proximity detection systems. The addition of these d&qualifiers reduced the target problem size of the crossing path and encroachment type backing crashes as shown in **Figure ES-4:**

Figure ES-4

AU Backing Crashes: 181,500
"Under Control" Backing Crashes: 169,000



Involvement of Different Vehicle Types

The above statistics relate to all vehicle types combined. The report also presents problem size statistics on "under control" encroachment backing crashes for several major vehicle type categories, including passenger vehicles (here defined as cars, light trucks, and vans), combination-unit trucks (i.e., tractor-trailers), and single-unit medium/heavy trucks. Passenger vehicles represent the majority of vehicle involvements, although single-unit trucks have the highest rate of involvement per vehicle mile traveled,. and combination-unit trucks have the highest expected number of involvements during the operational life of the average vehicle. The high expected number of involvements for combination-unit trucks compared to single-unit trucks reflects their higher mileage exposure.

A comparison of vans versus other passenger vehicles shows that approximately 2.3 times as many vans were involved in "under control" encroachment backing crashes compared to their involvement in all other crashes (e.g. 17.4 percent versus 7.7 percent, respectively). Annual involvements in this crash type per 1,000 registered vehicles are about 2.6 times greater for vans than for other passenger vehicles. Thus, vans, like medium/heavy trucks, are over-involved in these target crashes.

Crash Characteristics

Descriptive statistics are provided for "under control" encroachment backing crashes disaggregated by the three vehicle types. Some notable statistical differences across the three subtypes are apparent, even though all three types occur largely during daytime with no adverse weather conditions or other major environmental contributing factors.

Backing crash involvement rates (per 100 million VMT) were calculated for various driver age and sex groups. Higher involvement rates were found for younger (aged 15 to 19) and older (aged 75 and older) drivers. Overall, males had a higher involvement rate (7.5 per 100 million vehicle miles traveled) than females (4.3) as the backing vehicle driver.

The Indiana Tri-Level study (Treat et al, 1979) included just four in-depth backing crash cases; all involved the crash cause "recognition error/improper lookout." That is, the driver of the backing vehicle either "failed to look" or "looked but didn't see." Other studies corroborate the predominant role of failure to perceive in backing crashes.

Appendices

Appendices to the report provide detailed definitions and explanations of all statistics and data retrieval specifications used, statistics on all crashes (i.e., the "universe" of crashes), generalized estimated sampling errors for the 1990 GES, and reference citations.

1. INTRODUCTION

This document presents problem size assessments and statistical crash descriptions for backing crashes and several key subtypes of backing crashes. Backing crashes, particularly those involving slow closing speeds (e.g., vehicle backing out of driveway runs over unseen toddler) are potential "target crashes" of high-technology Intelligent Vehicle Highway System (IVHS) crash avoidance countermeasures. The proximity detection countermeasure concept (e.g., detection of obstacles in the rear blind zone through the use of radar, ultrasound, or similar technologies) appears to be especially applicable to this crash type. In this report, the backing crash problem size is assessed using such measures as number of crashes, number and severity of injuries, number of fatalities, crash involvement rate (per 100 million vehicle miles of travel), and crash involvement likelihood (e.g., annual number of involvements per 1,000 vehicles). Backing crashes are described statistically primarily in terms of the conditions under which they occur and, when data are available, in terms of possible contributing factors.

This problem size assessment and statistical description of backing crashes has been prepared in conjunction with an ongoing analytical process intended to determine the extent to which high-technology IVHS countermeasures can be employed effectively to prevent (and lessen the severity of) crashes, including backing crashes; This related countermeasure modeling work is described in a technical report by Tijerina et al (1993). The principal countermeasure concept examined by Tijerina et al is proximity detection.

Most statistics provided in this report are estimates based on national crash databases, such as the 1990 NHTSA General Estimates System (GES). Applicable crash fatality counts from the 1990 Fatal Accident Reporting System (FARS) are also presented. Both GES and FARS statistics address only police-reported crashes, although a rough estimate of the non-police-reported backing crash population is provided in this report based on a new estimation procedure for these crashes.

The provision of crash statistics for backing crashes and other topics implies that the crash problem in question can be stated and quantified in terms of existing database variables/elements to an acceptable degree of accuracy. In practice, accuracy will vary, based primarily on how well crash database variables and definitions correspond to the target crash type of the conceived countermeasure. In some cases, a problem size assessment may represent a target crash type that is broader, narrower, or otherwise different than that conceptualized according to the action of the countermeasure on driver or vehicle response. Thus, baseline problem size assessments may be modified based on additional information as part of the problem definition/countermeasure technology assessment process.

For example, this report will initially present the entire backing crash' population, but then divide the overall problem into two types:

1) Slow closing-speed ***encroachment*** backing crashes that appear to be highly applicable to proximity detection countermeasures, and

2) ***Crossing path*** backing crashes involving higher closing speeds and questionable applicability to proximity detection countermeasures.

Furthermore, the encroachment backing crash type is further classified into subtypes, and examined using additional qualifiers to obtain a narrow target crash population of only those crashes where the vehicle is likely to be "under control" and thus potentially preventable by an obstacle detection system.

In summary, the crash problem statistics presented in this report are intended to be compatible with ongoing countermeasure modeling/effectiveness estimation efforts. This information supports the assessment of potential safety benefits of crash prevention approaches and also helps to define the conditions under which countermeasures must operate in order to be effective.

The remainder of this report is organized as foliows:

- Chapter 2 classifies backing crashes, presents data on crash problem size, and disaggregates the backing crash problem size into subtypes relevant to countermeasure applicability.
- Chapter 3 provides descriptive statistics regarding encroachment detection-applicable backing crashes and three major subtypes. This includes crash involvement rates for various driver age and gender groups.
- Chapter 4 recounts statistics from the Indiana Tri-Level study on the causes of backing crashes.
- Appendix A describes the statistics used to quantify and describe the backing and other target crash problems.
- Appendix B provides a problem size assessment for ***all*** crashes, the "universe" of the U.S. crash problem, in accordance with the above statistical measures.
- Appendix C defines and presents data retrieval specifications for backing crash types/subtypes for GES and FARS.
- Appendix D is a technical note explaining GES sampling errors and providing tables of GES standard errors of estimate.
- Appendix E is a reference section listing publications cited or otherwise relevant to this report.

2. BACKING CRASH PROBLEM SIZE AND TYPES

This chapter presents an overall problem size assessment for backing crashes and several disaggregations of the backing problem into different types and subtypes. Backing crashes are divided into scenario types to provide a taxonomy for the analysis of collision causal factors and dynamics and for countermeasure modeling. The first major type consists of **encroachment** backing crashes. In these crashes a backing vehicle strikes a stationary or slow-moving object (person, vehicle, or fixed object). Usually, these crashes involve low closing speeds; they are potentially addressable by high-technology countermeasures such as rearward-scanning proximity detection systems, as well as some relatively low-technology countermeasures such as auditory backing-vehicle warnings. **The encroachment backing crash** type **(Category 1)** includes the following subtypes:

- **la.** **Pedestrian/pedalcyclist:** vehicle backs into a pedestrian or pedalcyclist.
- **lb.** **Parallel path,** struck vehicle: backing vehicle strikes front of stationary or very slow-moving vehicle.
- **lc.** **Curved path,** struck stationary vehicle or object: backing vehicle strikes side, corner, or back of other vehicle or strikes object. Such backing vehicles are usually following a curved path (i.e., turning) while backing out of driveway or parking space.

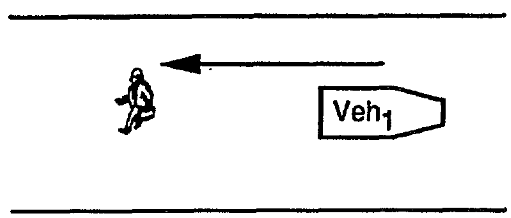
  Section 2.2 contains an explanation of the rationale for the use of the terms “parallel path” and “curved path” for the above two crash subtypes.

In addition, a **crossing-path backing crash type (Category 2)** was identified. In these crashes, a backing vehicle strikes or is struck by a forward-moving vehicle generally traveling in a perpendicular direction. In other words, the two vehicles collide because their travel paths cross and one vehicle fails to yield. These crashes are more difficult to address with the types of countermeasures described above; in most cases the non-backing vehicle is traveling much faster than the backing vehicle and/or is closing from the side of the backing vehicle rather than the rear. Thus, the other vehicle would generally not enter the rear-blind-zone detection area of an obstacle detection system or would be closing too fast for an obstacle detection warning to enab1e a driver to react to avoid a crash. Of course, crossing-path backing crashes may be amenable to prevention using other countermeasure concepts such as forward obstacle detection systems (installed in the non-backing vehicle). **Figure 2-1** illustrates the backing crash types and subtypes.

Problem size measures such as number of crashes, injuries, and fatalities were derived directly from GES and FARS. The reader may refer to **Appendix A** for explanationsof the statistical metrics used and **Appendix C** for data specifications of backing crash types and subtypes in GES and FARS.

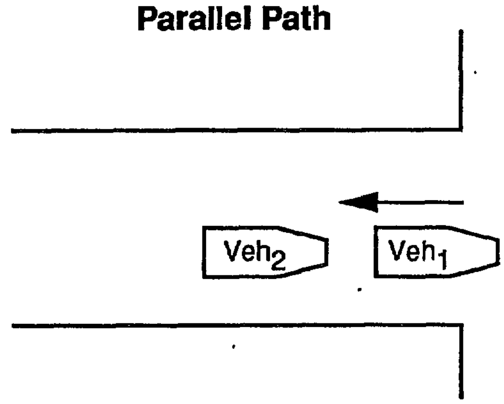
Figure 2-1
Backing Crash Types and Subtypes

Encroachment: Pedestrian/Pedalcyclist



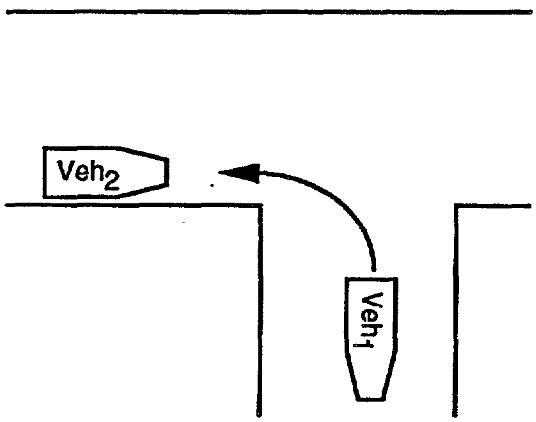
- Pedestrian or pedalcyclist behind Veh_1
- Veh_1 backs & hits pedestrian or pedalcyclist

Encroachment: Parallel Path



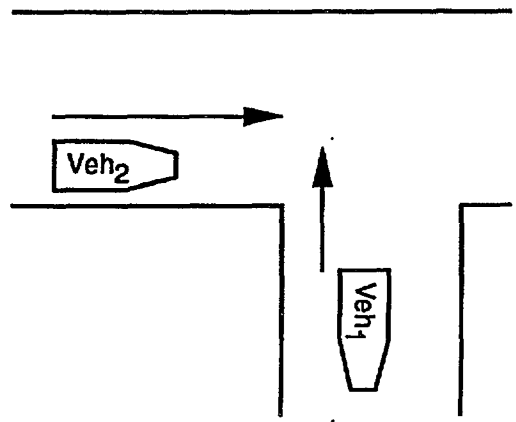
- Veh_1 & Veh_2 on roadway, traveling in same lane in same direction
- Veh_1 stops
- Veh_1 reverses direction & hits Veh_2

Encroachment: Curved Path



- Veh_2 stationary
- Veh_1 backs into Veh_2

Crossing Path



- Veh_2 traveling on roadway
- Veh_1 backs into Veh_2 or is struck by Veh_2

2.1 Overall Problem Size

This section contains an estimate of the overall backing crash problem size based on available data files (GES and **FARS)** and a discussion of the problem of "non-traffic" backing crashes, which constitute a large but poorly-quantified population of backing crashes.

2.1.1 Problem Size Statistics Based on Data Retrievals

This section presents an overall problem size assessment for all backing crashes (i.e., encroachment and crossing-path combined) based on GES and FARS. GES statistics encompass all crashes involving a vehicle with Accident Type (V23, ACC-TYPE) 92 (backing vehicle). **FARS** statistics encompass all fatal crashes involving a vehicle with the Vehicle Maneuver (VEH_MAN) 15 (Backing Up).

All statistics regarding crashes and non-fatal injuries provided in Tables 2-l through 2-4 of this chapter were rounded to the nearest 500. As a result of rounding, some table entries may not sum to the posted totals. In addition, percentage estimates and the derived statistics in the tables were calculated before numbers were rounded.

Table 2-1 shows the following:

- In 1990, there were 181,500 police-reported backing crashes (Standard Error = l5,127), which constituted 2.8 percent of all police-reported crashes.

- There were 185 associated fatalities, which constituted 0.4 percent of all fatalities.

- Backing crashes were associated with approximately 772 fatal crash equivalents (see Appendix A for definition).

- About 91.0 percent of backing crashes were property damage only.

- The involvement rate as the subject (backing) vehicle is 8.4 involvements per 100 million vehicle miles, traveled.

- The expected number of involvements (as the backing vehicle) over a vehicle's operational life was 0.0123. This value approximates the percentage of vehicles would be involved in a police-reported backing crash (as the backing vehicle) during their operational lives --'i.e., approximately one percent.

- Backing crashes appear to account for a small percentage -- about 1 percent -- of all crash-caused delay.

TABLE 2-1
PROBLEM SIZE STATISTICS FOR ALL BACKING CRASHES
INVOLVED VEHICLE TYPES: ALL VEHICLES

GES/FARS-Based Statistics (1990)		*All* Backing Crashes
Annual # PR Crashes (GES)	Total:	181,500
	Injury:	16,500
	PDO:	165,000
Annual # Fatalities (FARS)		. 185
Ann. # Non-Fatal PR Injuries (GES)	Total:	22,000
	A:	1,500
	B:	5,500
	C:	15,000
Fatal Crash Equivalents		772
Percentage of All PR Crashes		2.81%
Percentage of All FCE		0.86%
Percentage of All Fatalities		0.41%
Involvements as "Subject (Backing) Vehicle":		
Involvement Rate Per 100 Million VMT		8.4
Annual Involvements Per 1,000 Registered Vehicles		0.94
Expected # Involvements During Vehicle Life		0.0123
Estimated Annual # NPR Crashes	Total:	297,500
	Injury:	35,000
	PDO:	262,500
Estimated Total Annual Target Crashes (PR + NPR)	Total:	479,000
	UDH:	17,000
	Non-UDH:	462,000
Crash-Caused Congestion (Delay)	Veh-Hours:	4.1 M
Percentage of All Crash-Caused Delay		0.90%

Legend:

A	Incapacitating Injuries	M	Million
B	Nonincapacitating Injuries	NPR	Non-Police Reported
C	Possible Injuries	PDO	Property Damage Only
FARS	Fatal Accident Reporting System	PR	Police Reported
FCE	Fatal Crash Equivalent	UDH	Urban Divided Highway
GES	General Estimates System	VMT	Vehicle Miles Traveled

2.1.2 Non-Police-Reported/Off-Roadway Backing Crashes

Table 2-1 provides an estimate of 297,500 for non-police-reported backing crashes. This estimate is based on the estimation algorithm described under Item 9 of Appendix A. However, as noted in Appendix A, the algorithm likely underestimates crash types like backing crashes. There are at least two reasons for this likely underestimation: 1) Backing crashes are frequently low-speed, low-severity crashes, and thus fall below reporting thresholds; and 2) Many backing crashes occur off-roadway on private property, in particular driveways and parking lots. The situation is complicated by the fact that the distinction between “police-reported” and “non-police-reported” is not always clear. For example, some off-roadway backing crashes are reported to the police but never investigated nor included in automated accident data files.

In addition to the large but unknown number of non-police-reported low-severity backing crashes, there is a significant (but again, unknown) number of off-roadway pedestrian backing crashes, very often involving children. The most common scenarios for these are “home driveway backing” and “parking lot backing” (Walker, 1993). Problem size estimation for these off-roadway pedestrian backing crashes is extremely problematic because many of them occur on private property and are considered “non traffic” crashes. They are known, however, to involve a relatively high percent of severe injuries and fatalities (Walker, 1993; Brison et ***al,*** 1988).

Richardson and Edwards (1990) estimated the total annual number of non traffic non-occupant motor vehicle fatalities to be 420 for the years 1985-86, but the proportion of these that were backing crashes was unknown. A rough estimate based on Brison et ***al*** (1988) is that 25 to 50 percent were backing-related -- i.e., roughly 100 to 200 fatalities per year. Most of these non traffic-related pedestrian backing crash fatalities involve children below the age of five (Brison et al, 1988). A more recent study of non traffic crashes by Walker (1993) generally corroborated this estimate, as well as the high involvement of young children. Interpolations of data from the Walker (1993) study indicate that annual non-fatal injuries from these crashes are likely to be in the 500 to 1,500 range.

2.2 Problem Size: Backing Crash Types/Subtypes

This section presents the backing crash problem classified by the crash type/subtype scheme described earlier. The types/subtypes are:

1. **Encroachment backing crashes (Category 1)**

   la. **Pedestrian/pedalcyclist:** vehicle backs into a pedestrain or pedalcyclist.

lb. **Parallel path,** struck vehicle: backing vehicle strikes front of stationary or very slow-moving vehicle.

lc. **Curved path,** struck stationary vehicle or object: backing vehicle strikes side, corner, or back of other vehicle or strikes object (e.g., ‘while backing out of driveway or parking space into the street).

2. **Crossing-path backing crashes (Category 2).**

Appendix C provides detailed data specifications of the above crash subtypes per the GES and FAR data files. The terms “parallel path,” “curved path,” and “crossing-path” are intended to describe the ***predominant*** vehicle movements for these subtypes, but they are not themselves the basis of the data specifications since such descriptions of the pre-crash path (e.g., straight versus curved) are not contained in GES or FARS. The terms “parallel path, “curved path,” and “crossing-path” arose from examinations of’ individual backing crash case files conducted by Tijerina et ***al*** (1993) as part of the related countermeasure assessment program and are used here in order to maintain consistency with that analysis. The data retrieval specifications provided in Appendix C attempt to operationally define these backing crash scenarios in terms of available variables and data elements of the data files.

Table 2-2 presents 1990 statistics for the backing crash types and subtypes over all vehicle types. Table 2-2 shows the following:

- About 78,000 encroachment backing crashes were reported by police (Standard Error = 7,660), which comprised 43.0 percent of all backing crashes:
  - 3,000 (4.0 percent) pedestrian/pedalcyclist crashes (subtype la)
  - 44,000 (56.0 percent) parallel path, struck vehicle crashes (subtype lb)
  - 31,500 (40.0 percent) curved path, struck stationary vehicle or object (subtype lc).

- There were 112 associated fatalities resulting from encroachment backing crashes:
  - 100 of which involved struck pedestrians or pedalcyclists pedestrian/pedalcyclist subtype crashes)
  - 1 fatality resulted from parallel path subtype crashes
  - 11 fatalities resulted from curved path subtype crashes.

- Encroachment backing crashes were associated with approximately 341 fatal crash equivalents (see Appendix A for definition):
  - 159 for the pedestrian/pedalcyclist subtype
  - 98 for the parallel path subtype
  - 84 for the curved path subtype.

TABLE 2-2
PROBLEM SIZE STATISTICS FOR BACKING CRASH TYPES/SUBTYPES
INVOLVED VEHICLE TYPES: ALL VEHICLES

ES/FARS-Based Statistics (1990)		la Ped/Cyc	lb Parallel Path, Veh	lc Curved Path Veh or Obj	1 Total Encroach-ment	2 Crossing-Path
Annual # PR Crashes (GES)	**Total:**	3,000	44,000	31,500	78,000	103,500
	Injury:	2,500	2,000	**1,500**	6,000	l0,500
	PDO:	500	42,000	29,500	72,000	93,000
Annual # Fatalities (FARs)		**100**	1	11	**112**	73
Am. # Non-Fatal PR Injuries (GES)	Total:	2500	2500	2,000	7,000	l5,500
	A:	500	0	0	500	1,000
	B:	1,000	500	500	2,000	4,000
	C:	1,000	2,000	1,500	4,500	10,500
Fatal Crash Equivalents		159	**98**	**84**	341	**431**
Percentage of All PR Crashes		**0.04%**	0.68%	0.49%	1.21%	1.60%
Percentage of All FCE		**0.18%**	0.11%	0.09%	0.38%	0.48%
Percentage **of All Fatalities**		0.22%	0.00%	0.02%	0.25%	0.16%
Involvements as "Subject (Backing) Vehicle":						
Involvement Rate Per 100 Million VMT		0.1	2.0	**1.5**	**3.6**	4.8
Annual **Involvements Per 1,000** Registered Vehicles		0.01	0.23	0.16	0.40	0.54
Expected # Involvements During Vehicle Life		0.0002	0.0030	0.0021	0.0053	0.0070
Estimated Annual # NPR Crashes	**Total:**	500	75,500	53,500	129,500	168,000
	Injury:	0	9,000	6,500	l5,500	20,000
	PDO:	500	66,500	47,000	114,500	148,000
Estimated Annual Target Crashes (PR + NPR)	**Total:**	3,500	119,500	85,000	208,000	271,000
	UDH:	0	8,000	2,500	10,500	7,000
	Non-UDH:	3,500	111,500	82,500	197,500	264,500
Crash-Caused Congestion (Delay)	Veh-Hours:	0.0 M	1.6 M	0.6 M	2.3 M	1.9 M
Percentage of All Crash-Caused Delay		0.01%	0.35%	0.14%	0.50%	0.40%

Legend:

A	Incapacitating Injuries	M	Million
B	Nonincapacitating Injuries	NPR	Non-Police Reported
C	Possible Injuries	PDO	Property Damage Only
FARS	Fatal Accident Reporting System	PR	Police Reported
FCE	Fatal Crash Equivalent	UDH	Urban Divided Highway
GES	General Estimates System	VMT	Vehicle Miles Traveled

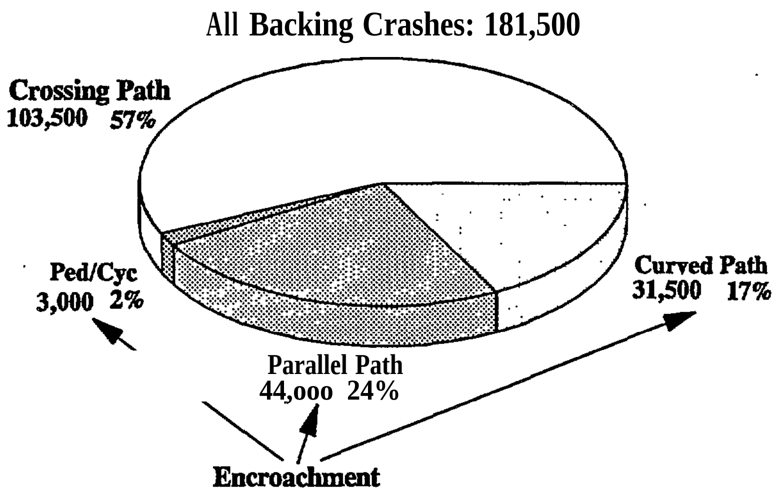
The caveats relating to non traffic backing crashes (in particular, pedestrian crashes) discussed in Section 2~1.2 are particularly relevant to the above fatality and fatal crash equivalent statistics.

- There were approximately 103,500 police-reported crossing-path backing crashes (Standard Error = 9,935) and 73 associated fatalities. .

- Crossing-path backing crashes were associated with 431 fatal crash equivalents.

Figure 2-2 shows graphically the relative crash problem sizes of these crash types and subtypes.

Figure 2-2. Backing Crash Types and Subtypes



2.3 Backing Crash Types/Subtypes: "Under Control" Backing Vehicle

This section presents the backing crash problem classified by the same crash type/subtype scheme presented above. However, additional "disqualifiers" are added to the target crash definitions to eliminate crashes where the backing vehicle was potentially ***not under control*** and thus the driver would not be capable of responding to a collision warning. Thus, crashes involving icy/snowy roadway surfaces, selected vehicle defects, driverless vehicles, grossly-intoxicated drivers, and selected driver physical impairments are excluded from the problem sizes. A detailed data definition for "under control" (UC) backing vehicle is presented in Appendix C. For the encroachment backing crash type, the target crash problem size assessments presented in this section and the problem size statistics presented in **Table 2-3 are** intended to capture crashes potentially amenable to prevention with rear-blind-zone proximity detection systems. The crashes excluded are those which are not likely to be applicable to this countermeasure concept.

Figure 2-3 provides a graphic overview of the adjustment of the target crash problem size due to the addition of the "under control" disqualifiers.

Figure 23.

All Backing Crashes: 181,500
"Under Control" Backing Crashes: 169,000

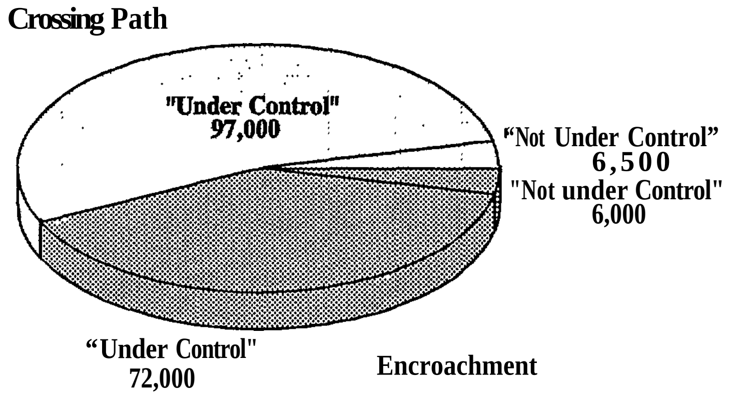


Table 23 presents 1990 statistics for the "under control" (UC) backing crash types and subtypes. Table 2-3 shows the following:

- There were approximately 72,000 police-reported UC encroachment backing crashes (Standard Error = 7,660).
- There were 85 fatalities resulting from UC encroachment backing crashes, 76 of which involved struck pedestrians or pedalcyclists (89.4 percent).
- There were approximately 6,500 associated non-fatal injuries (Standard Error = 1,150), including 500 serious (incapacitating) injuries.
- UC encroachment backing crashes were associated with approximately 285 fatal crash equivalents (see Appendix **A** for definition). .
- UC Encroachment backing crashes constituted about 1.1 percent of all police-reported crashes, 0.3 percent of total fatal crash equivalents, and resulted in 0.2 percent of all fatalities.
- During its operational life, a vehicle can be expected to be involved in 0.0049 police-reported UC encroachment backing crashes as the subject (i.e. backing) vehicle.

TABLE 2-3
PROBLEM SIZE STATISTICS FOR
"UNDER CONTROL" BACKING CRASH TYPES/SUBTYPES
INVOLVED VEHICLE TYPES: ALL VEHICLES

GES/FARS-Based Statistics (1990)		1a Ped/Cyc	1b Parallel Path, Veh	lc Curved Path Veh or Obj	1 Total Encroach-ment	2 Crossing-Path
Annual # PR Crashes (GES)	Total:	2,000	42,000	27,500	72,000	97,000
	Injury	2,500	,500	1,500	5,500	9,500
	PDO:	500	40,500	25,500	66,500	87,500
Annual # Fatalities (FARS)		76	1	8	85	64
Ann. # Non-Fatal PR Injuries (GES)	Total:	2,500	2,000	2,000	6,500	14,000
	A:	500	0	0	500	1,000
	B:	1,000	500	500	2,000	3,500
	C:	1,000	1,500	1,500	4,000	10,000
Fatal Crash Equivalents		131	88	66	285	407
Percentage of All PR Crashes		**0.04%**	**0.65%**	0.42%	1.11%	1.50%
Percentage of All FCE		**0.15%**	**0.10%**	0.07%	0.32%	0.45%
Percentage of All Fatalities		0.17%	0.00%	0.02%	0.19%	0.14%
Involvements as "Subject (Backing) Vehicle":						
Involvement Rate Per 100 Million VMT		0.1	2.0	1.3	3.4	4.5
Annual Involvements Per **1,000** Registered Vehicles		0.01	0.22	0.14	0.37	0.50
Expected # Involvements During Vehicle Life		0.0002	0.0029	0.0019	0.0049	0.0066
Estimated Annual # NPR Crashes	Total:	500	73,000	46,500	120,000	157,500
	Injury:	**0**	8,500	5,500	14,000	18,500
	PDO:	500	64,000	41,000	105,500	139,000
Estimated Annual Target Crashes (PR + NPR)	Total:	3,500	115,000	73,500	191,500	254,500
	UDH:	0	8,000	2,000	10,000	6,000
	Non-UDH:	3,000	107,000	71,500	181,500	248,500
Crash-Caused Congestion (Delay)	Veh-Hours:	0.0 M	1.6 M	0.5 M	2.2 M	1.6 M
Percentage of All Crash-Caused Delay		**0.01%**	0.33%	0.11%	0.45%	0.33%

Legend:

A	Incapacitating Injuries	M	Million
B	Nonincapacitating Injuries	NIJR	Non-Police Reported
C	Possible Injuries	PDO	Property Damage Only
FARS	Fatal Accident Reporting System	PR	Police Reported
FCE	Fatal Crash Equivalent	UDH	Urban Divided Highway
GES	General Estimates System	VMT	Vehicle Miles Traveled

- Per the non-police-reported crash estimation algorithm (see Appendix A), there were approximately 120,000 UC NPR encroachment backing crashes.

- About 5.0 percent of UC encroachment backing crashes (PR + NPR) occurred on urban divided highways. Not surprisingly, the encroachment backing crashes accounted for less than one percent (0.4 percent) of all crash-caused delay.

In comparing the different encroachment backing crash subtypes, the following problem size statistics are notable:

- For police-reported UC encroachment backing crashes, there were about 2,500 pedestrian/pedalcyclist crashes (subtype la), 42,000 parallel path vehicle (subtype lb) crashes, and 27,500 curved path struck stationary vehicle or object (subtype lc) crashes.

- Nearly 88.7 percent of subtype la (ped/cyc) were injury crashes, while most crashes for subtypes lb (parallel path, veh) and lc (curved path, vehicle or object) crashes were PDO.

- Subtype la (Ped/cyc) crashes accounted for 0.2 percent of all crash fatalities, which is the highest in this group.

- Within the encroachment category (Category l), Subtype lb (parallel path, vehicle) was most numerous (42,000 in 1990) and caused the most hours of delay.

Finally, the following comparisons between the UC encroachment backing crash category (three subtypes combined) and the crossing-path category are notable:

- Most of the UC backing crashes, encroachment and crossing-path alike, were property damage only crashes.

- Each UC backing crash category constituted less than 2.0 percent of all police-reported crashes during 1990. Encroachment backing crashes constituted about 1.1 percent of all police-reported crashes, slightly less than the crossing-path backing crash type (1.5 percent). However, encroachment backing crashes were associated with a slightly higher percentage of all fatalities (0.19 percent) than were the crossing-path backing crash type (0.14 percent).

- UC crossing-path backing crashes were associated with 64 fatalities, which is less than UC encroachment backing crashes (85 fatalities). However, UC crossing-path backing crashes had slightly higher FCEs (407 FCEs) which was due to a higher number of crashes and injuries.

- Each UC backing crash category accounted for less than 1 percent of all crash-caused delay.

- Even though UC crossing-path backing crashes were more numerous than UC encroachment backing crashes, they caused less estimated delay (1.6 million vs. 2.2 million vehicle-hours).

2.4 Vehicle Type Comparisons: Encroachment Backing Crashes Involving "Under Control" Backing Vehicles

This section presents vehicle type comparisons for the **encroachment** (Category 1) backing crash type involving an "under control" (UC) backing vehicle as presented in Section 2.3. In order to focus on vehicle type comparisons, statistics for the three encroachment backing subtypes have been aggregated. The first comparison presented is among passenger vehicles, combination-unit medium-heavy trucks, and single-unit medium/heavy trucks. The second comparison is between light vans and other passenger vehicles.

2.4.1 Passenger Vehicles Versus Medium/Heavy Trucks

Table 2-4 shows comparable statistics on encroachment backing crashes involving "under control" (UC) backing vehicles by three'different vehicle types: passenger vehicles (cars, light trucks, vans), combination-unit trucks, and single-unit trucks. It indicates that:

- In terms of absolute numbers of involvements in target crashes (as the striking vehicle), there were far more passenger vehicle involvements (59,000) than combination-unit truck (5,000) or single-unit truck (6,000) involvements.

- UC Encroachment backing crash involvements as the striking vehicle constituted a larger percentage of all crash involvements for medium/heavy trucks. than for passenger vehicles. The percentages were:
  - Passenger vehicles 0.9 percent
  - Combination-unit trucks 2.3 percent
  - Single-unit trucks 4.0 percent.

- Based on vehicle miles of travel, single-unit trucks had highest target crash involvement rate (11.3 per 100 million VMT) as the striking vehicle, compared to 5.2 for combination-unit trucks and 3.0 for passenger vehicles.

- Per 1,000 registered combination-unit trucks, there were 3.14 target crash involvements (as the striking vehicle), versus 1.43 per 1,000 single-unit trucks and 0.32 for every 1,000 passenger vehicles.

TABLE 2-4
PROBLEM SIZE STATISTICS FOR "UNDER CONTROL" ENCROACHMENT BACKING CRASHES VEHICLE TYPES INVOLVED AS THE STRIKING VEHICLE: PASSENGER VEHICLES, COMBINATION-UNIT TRUCKS, SINGLE-UNIT TRUCES

GES/FARS-Based Statistics (1990)		Passenger Vehicles	Combination-Unit Trucks	Single-Unit Trucks	All Vehicles
Annual # PR Crashes (GES)	Total:	58,500	5,000	6,000	72,000
	Injury:	4,500	500	500	5,500
	PDO:	54,500	4,500	5,500	66,500
Annual # Fatalities (FARS)		58	6	16	85
Ann. # Non-Fatal PR Injuries (GES)	**Total:**	**5,000**	500	500	6,500
	A:	500	0	0	500
	B:	1,500	0	0	2,000
	C:	3,000	500	500	4,000
Fatal Crash Equivalents		238	13	28	285
Percentage of All PR Crashes		**0.93 %**	2.26%	3.99%	1.10%
Percentage of All FCE		0.28%	0.26%	1.13%	0.32%
Percentage of All Fatalities		0.14%	0.14%	1.45%	0.19%
Involvements as "Subject (Backing) Vehicle":					
Involvement Rate Per 100 Million VMT		3.0	5.2	11.3	3.4
Annual Involvements Per 1,000 Registered Vehicles		0.32	3.14	1.43	0.37
Expected # Involvements During Vehicle Life		0.0042	0.0461	0.0211	0.0049
Estimated Annual # NPR Crashes	Total:	98,000	8,500	**10,000**	**120,000**
	Injury:	**11,500**	**1,000**	**1,000**	**14,000**
	PDO:	86,500	7,500	8,500	105,000
Estimated Annual Target Crashes (PR + NPR)	Total:	157,000	13,500	16,000	191,500
	UDH:	6,500	1,000	2,500	**10,000**
	Non-UDH:	**150,500**	12,500	13,500	181,500
Crash-Caused Congestion (Delay)	**Veh-Hours:**	**1.5** M	0.2 **M**	**0.5** M	2.2 M
Percentage of All Crash-Caused Delay		0.32%	0.05%	**0.10%**	0.43%

Note: In this and similar tables, the percentages provided for all PR crashes, all FCE, and all fatalities are vehicle-type-specific e.g., target passenger vehicle crashes as a percentage of all passenger vehicle crashes. In contrast, the percentage provided for all crash-caused delay is based on all vehicle types combined. See Appendix A for more detail.

Legend:

A	Incapacitating Injuries	M	Million
B	Nonincapacitating Injuries	NPR	Non-Police Reported
C	Possible Injuries	PDO	Property Damage Only
FARS	Fatal Accident Reporting System	PR	Police Reported
FCE	Fatal Crash Equivalent	UDH	Urban Divided Highway
GES	General Estimates System	VMT	Vehicle Miles Travel

- Based on these 1990 statistics, the expected number of involvements during a combination-unit truck life time was 0.0461, which was twice the value for single-unit trucks and ten times that for passenger vehicles.

Appendix A contains definitions and explanations of the statistical metric "involvement rate" and the two "likelihood" metrics used above: 1) Involvements per 100 registered vehicles and 2) Expected number of involvements over vehicle life.

Figures 2-4,2-5, and 2-6 present a graphic overview of the UC encroachment backing crash picture from the perspective of these three key vehicle type categories. **Figure 2-4** shows UC encroachment backing crash involvements by the vehicle type of the backing vehicle. It shows that passenger vehicles represent the largest portion of the overall problem. **Figure 2-5** presents crash involvement rates per 100 million VMT, and shows that single-unit trucks have the highest rate. **Figure** 2-6 presents expected numbers of involvements over vehicle operational life, and shows that combination-unit trucks have the highest expected number of involvements per vehicle. The high expected number of involvements for combination-unit trucks compared to single-unit trucks reflects their high exposure; combination-unit trucks travel an average of 60,032 miles annually versus 12,683 for single-unit trucks (see Appendix A for more detail on exposure statistics). Even though involvement *rate* per 100 million VMT is higher for single-unit trucks, the difference in exposure makes combination-unit trucks more likely to be involved.

Figure 2-4.
UC Encroachment Backing Crash Involvement by Type of Backing (Striking) Vehicle

All Involvements: 72,000

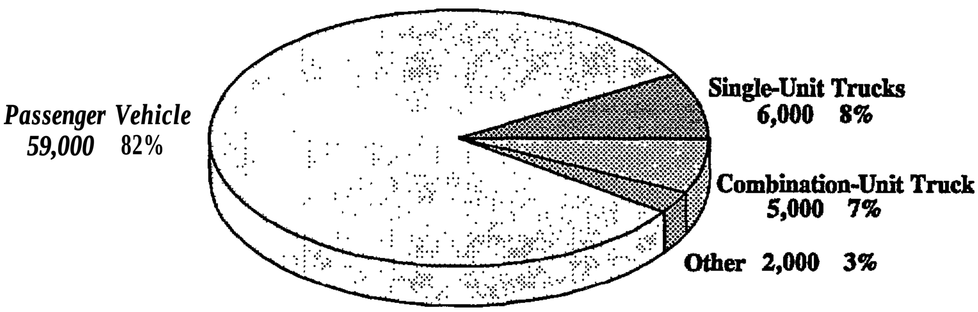


Figure 2-5.
UC Encroachment Backing Crash Involvement Rate (Per 100 Million VMT) by Vehicle Type

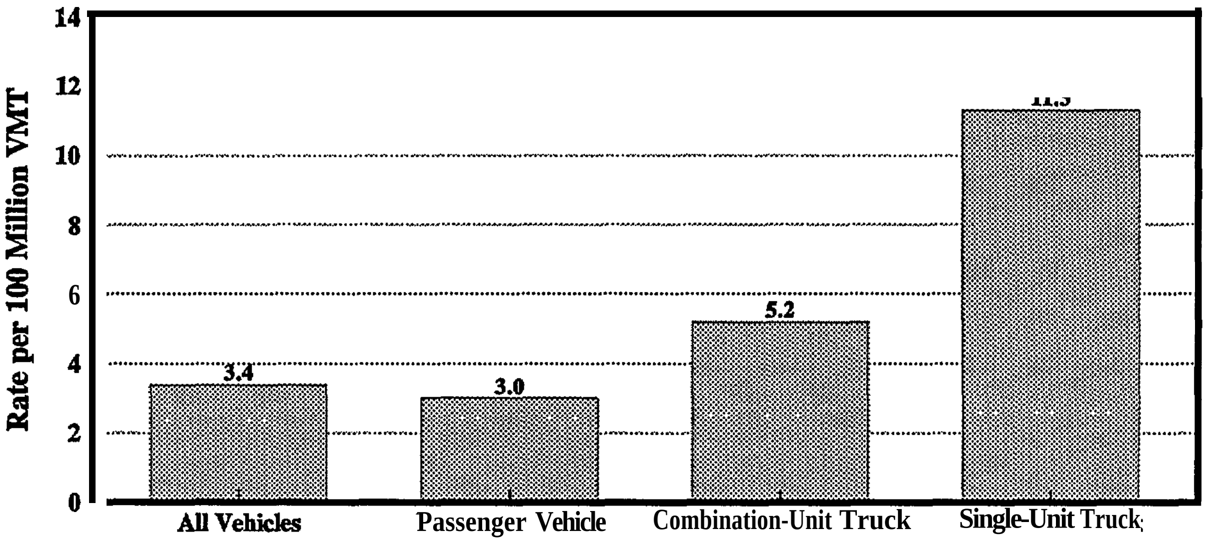
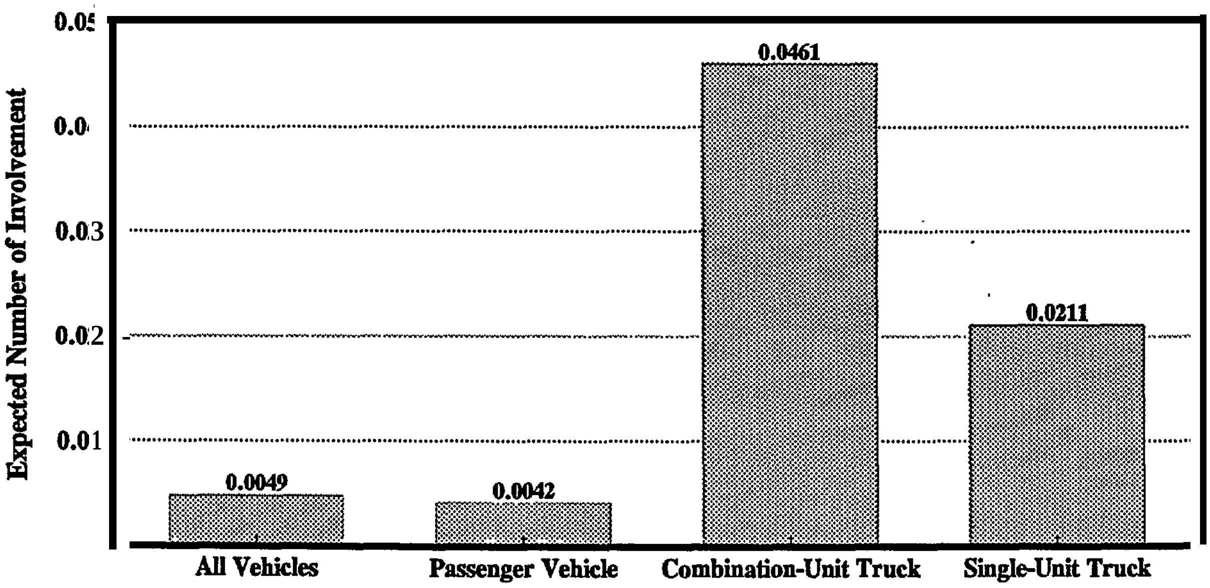


Figure 2-6.
Expected Number of UC Encroachment Backing Crash Involvements Over Vehicle Operational Life by Vehicle Type



2.4.2 Vans Versus Other Passenger Vehicles

Because the rear visibility of vans is often limited, the question arises as to whether vans are overrepresented in encroachment backing crashes (as the backing vehicle). However, lack of readily-available and reliable mileage data prevented the calculation of involvement rates as presented in previous tables. Therefore, only relative crash frequency distributions and likelihood statistics for these two vehicle types -- vans and passenger vehicles other than vans -- are presented here. **Table** 2-5 presents overall involvements in encroachment backing crashes (backing vehicle "under control") against involvements in all other crashes. As can be seen in Table 2-5, the percentage of vans involved in these crashes (as the striking vehicle) was more than twice the percentage of their involvement in other crashes.

TABLE 2-5
CRASH DISTRIBUTION:
OTHER PASSENGER VEHICLES VERSUS VANS

Vehicle Type	Encroachment Backing Crashes (Backing Vehicle "Under Control")	Other Crashes
Passenger Vehicles (other than vans)	82.6%	92.3%
Vans	17.4%	7.7%
rot al	100.0%	100.0%

(Note: The column percentages for UC encroachment backing crashes in Table 2-5 are percentages of the involved subject vehicle as the striking vehicle. But for the column of other crashes, the percentages represent the distribution of involved vehicles regardless of vehicle role.)

Table 2-6 shows that the annual involvement in UC encroachment backing crashes per 1,000 registered vehicles is more than 2.5 times greater for vans than for other passenger vehicles.

TABLE 2-6
"UNDER CONTROL" ENCROACHMENT BACKING CRASHES
OTHER PASSENGERVEHICLES VERSUS VANS

Vehicle Type	Annual Involvements per 1,000 registered vehicles
Passenger Vehicles (other than vans)	0.39
Vans	1.02

(Note: Highway Statistics (published by PHWA) lacks van registration information. Therefore, vehicle registrations in the National Vehicle Population Profile data base (copyright R.L. Polk & Co.) were used here to calculate annual involvements per 1,000 vehicles.)

3. “UNDER CONTROL” ENCROACHTMENT BACKING CRASH DESCRIPTIVE STATISTICS

GES bivariate distributions were obtained for “under control” (UC) **encroachment** backing crashes, based on the disaggregation defined in Chapter 2:

- **la. Pedestrian/pedalcyclist.**
- **lb. Parallel path, struck vehicle.**
- **1c. Curved path, struck stationary vehicle or object.**

Data on UC encroachment backing crashes from both the 1990 and 1991 GES were obtained and aggregated in order to provide more reliable statistics on crash characteristics. All the statistical findings presented in this chapter are based on a non-weighted sample size of 708 crashes: 89 Subtype la, 400 Subtype lb, and 219 Subtype lc crashes. **See Table 3-1** for a more detailed distribution of encroachment backing subtypes. Because of small sample sizes, especially for the crash Subtype la, the statistical significance of the data is affected.

TABLE 3-1. 1990-1991 GES Non-Weighted UC Encroachment Backing Crashes

Year	**la Ped/Cyc**	**lb Parallel Path, Veh**	**lc Curved Path, Veh or Object**	**1 Total Encroachment (la+lb+lc)**
GES 1990	50	203	123	376
GES 1991	39	197	96	332
Total	89	400	**219**	708

All data on UC encroachment backing crashes are for all vehicle types combined. When available, ***imputed and Hotdeck imputed*** GES variables were used (i.e., variables with unknowns distributed proportionately across known values or assigned specific values using a “Hotdecking” methodlogy). Data relating to the following variables were obtained:

Imputed Time Blocks (i.e., 24:00-06:OO; 06:01-09:30; 09:31-15:30; 15:31-18:30; 18:31-23:59)
Imputed Day of Week (AlCI, WKDY_I)
Land Use (A05, LAND_USE)
Imputed Relation to Junction (AO91, RELJCT_I)
Trafficway Flow (Al 1, TRAF_WAY)
Hotdeck Imputed Speed Limit (A181, SPDLIM_H)

Imputed Light Condition (A191, LGTCON_I)
Imputed Atmospheric Condition (A201, WEATHR_I)
Imputed Violations Charged (D21, VLTN_I) to Driver of Striking Vehicle (vehicle with Imputed Vehicle Role [V22I, VROLE_I] = 1 [Striking])
Driver's Vision Obscured By . . . (D04, VIS_OBSC) for Driver of Striking Vehicle (Imputed Vehicle Role (V22I, VROLE-I) = 01)
Driver Distracted By . . . (D07, DR_DSTRD) for Driver of Striking Vehicle (Imputed Vehicle Role (V22I, VROLE_I) = 01)
Travel speed (Vl 1, SPEED) of Striking Vehicle (vehicle with Imputed Vehicle Role (V22I, VROLE-I) = 1 [Striking])
Travel speed (Vll, SPEED) of Struck Vehicle (vehicle with Imputed Vehicle Role (V22I, VROLE_I] = 2 [Struck])
Violations Charged (D02, VIOLATN) for Driver of Striking Vehicle (Imputed Vehicle Role (V22I, VROLE-I) = 01)
Hotdeck Imputed Most Harmful Event (V20I, E_VENT_H)
Hotdeck Imputed Age (P7H, AGE-H)
Hotdeck Imputed Sex (P8H, SEX_H)
Non-Motorist Location (P13, LOCATN) (Applicable only to Subtype la)
Non-Motorist Action (P19, ACTION) (Applicable only to Subtype la)

The following major findings are noted. For each specific variable (whether imputed or non-imputed), the percentage cited here is based on known/assigned values only.

- All three subtypes occurred most frequently between the hours of 9:31 to 15:30. The next most frequent hours of occurrence varied. The pedestrian/pedalcyclist subtype occurred frequently between the hours of 18:31 to 23:59, and the other two subtypes occurred frequently during the afternoon rush hour (15:31 - 18:30). **See Table 3-2.**

TABLE 3-2. Percent of Total UC Encroachment Backing Crashes by Time of Day

Time Block	la Ped/Cyc	lb Parallel Path, Veh	lc Curved Path, Veh or Object	1 Total Encroachment (la+ lb+ lc)
24:00 - 6:00	3.4	3.5	6.3	4.5
6:01 - 9:30	13.5	15.5	14.4	15.0
9:31 - 15:30	32.4	51.0	46.9	48.8
15:31 - 18:30	23.6	17.1	18.7	18.0
18:31 - 23:59	27.1	12.9	13.7	13.8
Total	100.0	100.0	100.0	100.1

- In general, UC encroachment backing crashes were less likely to occur on weekend days than on weekdays.

- Approximately 53.0 percent of target Ped/Cyc (Subtype la) crashes occurred in areas with population of 100,000 or greater, versus only 31.3 percent of Subtype lb and 26.6 percent of Subtype lc crashes.

- For Subtype lb crashes, nearly 96.1 percent of backing vehicles struck a stationary vehicle; only 3.9 percent of these crashes involved a vehicle backing into a slowly-moving vehicle.

- The most harmful events for all three crash subtypes are provided in **Table 3-3:**

Table 3-3. Percent of Total UC Encroachment Backing Crashes by Most Harmful Events

la Ped/Cyc	**lb Parallel Path, Veh**	**1c Curved Path, Veh or Object**
Pedestrian **76.6**	Motor Vehicle in Transport 100	Motor Vehicle in Transport **66.2**
Cyclist **23.4**		Fixed Object **33.2**

- Approximately 55.5 percent of Subtype lb crashes were intersection and intersection-related crashes. About 36.4 percent of Subtype lc and 29.5 percent Subtype la crashes were Driver/Alley access-related crashes, whereas only 8.0 percent of Subtype lb crashes were Drive/Alley access-related (Table **3-4).**

TABLE **3-4. Percent of Total UC Encroachment Backing Crashes by Relation to Junction**

Relation to Junction	**la Ped/Cyc**	**lb Parallel Path, Veh**	**lc Curved Path, Veh or Object**	**1 Total Encroachment (la+ lb+ lc)**
Non-Junction	**35.8**	**32.5**	**39.1**	**35.0**
Intersection & Related	**34.2**	**55.5**	**23.7**	**43.0**
Drive/Alley Access	29.5	**8.0**	**36.4**	19.1
Interchange Areas	**0.5**	**4.0**	**0.8**	**2.9**
Total	100.0	100.0	100.0	100.0

- Overall, about 79.7 percent of UC encroachment crashes occurred on level roadways.

- For each subtype, the percentage of crashes occurring in other than normal weather conditions represented less than 13.0 percent. Overall, about 89.6 percent of encroachment backing crashes occurred under no adverse conditions, 8.8 percent occurred during rain, and 1.6 percent occurred during sleet/snow/fog/smog weather conditions.

- About 81.8 percent of UC encroachment backing crashes occurred during daylight. Approximately 10.2 percent occurred under "dark but lighted" conditions, with Subtype la crashes somewhat more likely than the other two subtypes to occur under "dark but lighted" condition. Roughly 4.7 percent occurred after dark and 2.5 percent occurred at dusk, with Subtype la crashes occurring twice as often as the other two subtypes at dusk.

- Unknowns for the pre-crash travel speed of the striking vehicle were high, especially for Subtype la crashes. However, where striking vehicle travel speed was coded, the mean speed for the Subtype la was 9 mph, 3 mph for the Subtype lb, and 4 mph for the Subtype lc crashes **(Table 3-5).**

TABLE 3-5. UC Encroachment Backing Crashes Average Travel Speed of Striking Vehicle

	la Ped/Cyc	lb Parallel Patb, Veh	lc Curved Path, Veh or Object
Average Travel Speed	**9.0 mph**	**3.3 mph**	4.3 mph

- For all three subtypes, the average speed limit of roadways on which crashes occurred was 30-35 mph.

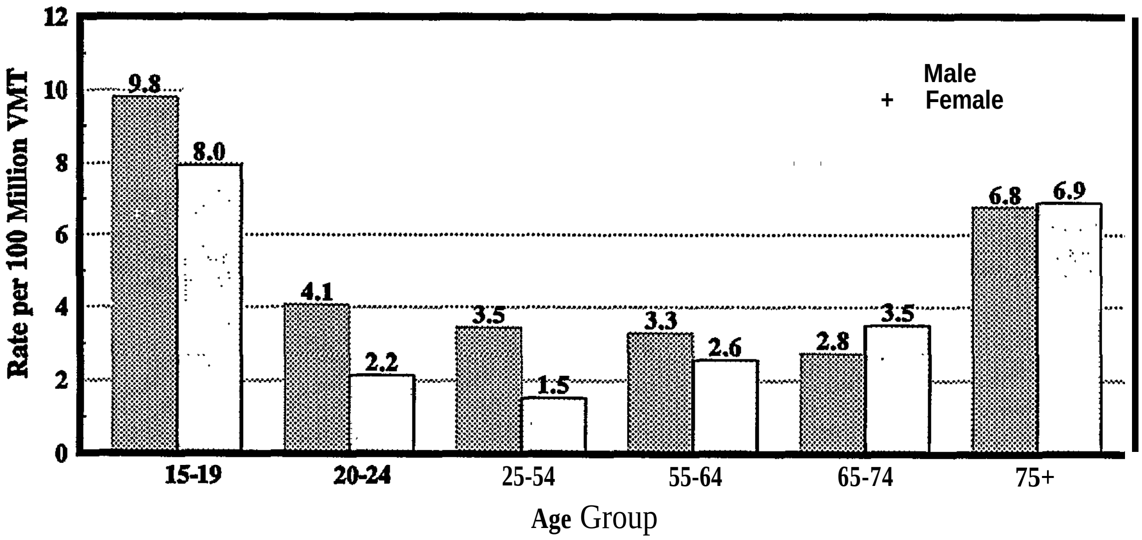
- About 27.4 percent of Subtype la crashes were Hit and Run. The percentage was much higher than the overall hit-and-run percentage for encroachment crashes (10.9 percent).

- For UC encroachment backing crashes overall, more than half (56.7 percent) of striking vehicle drivers were not charged with any violation.

- Obstruction of driver vision was reported in only about 2.6 percent of target crashes (hit & run crashes excluded).

- Figure 3-l shows the 1990-1991 distribution of crash involvement rates by age group for men and women as the backing vehicle driver. Higher involvement rates were found for younger (aged 15 to 19) and older (aged 75 and older) drivers. Before age 54, for both male and female drivers, the involvement rates decreased as age increased. After age 54, involvement rates for female drivers increased while male driver involvement rate still decreased until age 74 and then rose for age group 75 +. Overall, males had a higher involvement rate (3.8 per 100 million vehicle miles traveled) than females (2.2) as the backing vehicle driver. These involvement rates are based on total vehicle miles traveled, the standard measure of crash risk exposure. One caveat associated with the involvement rate statistics is that total VMT may not necessary reflect precisely the risk exposure specific to backing crashes (i.e., the number of backing maneuvers made) for different age and sex groups.

Figure 3-1. UC Encroachment Backing Crashes
Involvement Rate for Backing Vehicle by Driver Age and Sex



(Note: total vehicle miles traveled by age and gender group is not available for 1991, therefore, 1990 data are used for both 1990 and 1991 to calculate the annual crash involvement rates shown above).

- Pedestrian/pedalcyclist location at the time of impact was as follows:
  - Intersection:
    - -- On roadway (25.4 percent)
    - -- In crosswalk (1.0 percent)
    - -- Other (0.5 percent)
  - Non-intersection:
    - -- On roadway (50.5 percent)
    - -- In crosswalk (0.5 percent)
    - -- Other (13.2 percent)
  - Other location (8.8 percent).

- Pedestrian/pedalcyclist action indicated immediately prior to impact was:
  - No action (37.3 percent)
  - Walking/riding with or against traffic, playing, working, sitting, lying, standing in roadway (10.6 percent)
  - Operating without required equipment (1.1 percent)
  - Jogging (0.5 percent).
  - Other action (50.4 percent).

  (Note that police accident reports generally do not contain detailed information on pedestrian/pedalcyclist actions; hence the large number of "no action" and "other action" cases.)

4, TRI-LEVEL STATISTICS ON CRASH CAUSES

Of the 420 in-depth Indiana Tri-Level study cases (Treat et al, 1979 a; see section A.1.5 of Appendix A of this report), 4 (1.0 percent) were backing crashes. The Tri-Level statistics on crash causes for these four cases indicated that all four cases involved the cause "recognition error/improper lookout." Two of the four cases involved a vehicle pulling out from a parking place. The crash causes for these backing crashes are shown below.

Backing Crashes (4 cases):

- **Vehicular factors (1 case, 25%)**

  Communications Systems (1 case, 25%)
  - Vehicle-related vision obstructions (1 case, 25%)
  - Window design, placement (1 case, 25%)

- **Human causes (4 cases, 100%)**

  Direct human causes (4 cases, 100%)

  - Recognition errors (4 cases, 100%)
    - Recognition delays -- reasons identified (4 cases, 100%)
      - External distraction (1 case; 25%)

      - Improper lookout (4 cases; 100%)
        - Pulling out from parking place (2 cases, 50%)
        - Improper lookout -- other (2 cases, 50%)

  - Decision errors (1 case, 25%)
    - Improper maneuver (1 case, 25%)
      - Drove in wrong direction of travel (1 case, 25%)

Walker's (1993) report on non traffic child pedestrian crashes corroborates the Tri-Level findings. Examining a sample which included both "parking lot" and "driveway" backing scenarios, Walker found that drivers were rarely aware of the presence of the child behind the vehicle until after impact.

APPENDIX A: PROBLEM SIZE AND DESCRIPTIVE STATISTICS

Target crash problem size assessments and descriptive statistics are based on counts and estimates accessed from available crash datafiles. For target crash problem size assessment, raw statistics are typically manipulated statistically to provide more usable and comprehensive problem size statistics. This appendix describes the datafiles accessed and the statistical measures that are derived from those estimates.

A.1 Crash Datafiles and Other Information Sources Accessed

The following data sources have been used to estimate backing and "all crashes" problem size and descriptive statistics:

A.l.1 NHTSA General Estimates System (GES)

GES, one of the two major subsystems of the current National Accident Sampling System (NASS), is a survey of approximately 45,000 Police Accident Reports (PARs) from 60 geographic sites (jurisdictions) in the U.S. The PAR is the only source of data for GES. A data coder reviews the **PAR** and then codes the GES variables. GES is a comprehensive crash data file, addressing all vehicle and crash types and crash severities. Since the GES sample size is moderate (rather than large like the Crash Avoidance Research Data file; CARDfile), its reliability is greatest when relatively large crash problems are examined. For low-frequency crashes, the reliability of GES data may be questionable.

Estimates presented in this report have been rounded to nearest 500. As a result of rounding, some table entries may not sum to the posted totals. In addition, percentage estimates and the derived statistics in the tables were calculated before numbers were rounded.

Appendix D of this report is excerpted from a publication entitled "Technical Note for 1988, 1989, 1990 National Accident Sampling System General Estimates System" (DOT HS 807 796). Appendix C provides tables for estimating the standard errors of GES estimates. Although point estimates are provided in this report, it is critical to realize that each GES estimate (whether of crashes, vehicles, or injuries) has an associated sampling error. The tables in Appendix D can be used to derive, through interpolation, the standard error of each GES estimate (or the standard error of statistics derived from GES estimates). Estimation reliability improves with increasing crash/vehicle/injury: numbers; i.e., standard errors are smaller, relative to the estimate, for larger estimates.

A.1.2 NHTSA Fatal Accident Reporting System (FARS)

FARS is a census of data on all fatal crashes in the U.S. FARS contains descriptions of each fatal crash using 90 coded variables characterizing the accident, vehicle, and people involved. The PAR is the primary source of information on each fatal crash, although supplementary information is also used, such as medical reports on blood alcohol content when available. FARS statistics are crash/vehicle/fatality counts, not estimates. There is no associated standard error.

A.1.3 NHTSA NASS Continuous Sampling Subsystem (CSS)

The NASS Continuous Sampling Subsystem (CSS) was a nationwide accident data collection program sponsored by NHTSA. During the 1982436 timeframe, NASS CSS data were collected from 50 sites selected to be representative of the continental U.S. NASS crash investigations were regarded as "Level II" investigations; i.e., they were far more in-depth than police accident reports (Level I), but were not comprehensive in-depth investigations (Level III). NASS investigations emphasized crashworthiness and occupant protection concerns, but also collected useful information relating to crash causation. Approximately 12,000 cases were investigated each year. The sampling error problem discussed above for GES is even greater for NASS statistics. Therefore, the CSS is generally not a good source of statistics relating to problem size of low-frequency crash types. NASS CSS data are not cited in this report.

A.1.4 NHTSA NASS Crashworthiness Data System (CDS)

The NASS CDS is a nationally-representative sample of police-reported crashes occurring throughout the U.S. involving at least one towed passenger car, light truck, van or utility vehicle. CDS was implemented in 1988 as a follow-on to the NASS CSS (see above). CDS investigates about 5,000 crashes annually, proving detailed information on injuries and injury mechanisms. Consistent with its specific emphasis on crashworthiness, CDS provides more detailed information than CSS on vehicle damage and associated occupant injuries, but less information on accident circumstances (e.g., environmental conditions, collision scenarios). (Note, however, that CDS has added new variables on pre-crash events beginning with the 1992 data collection year).

CDS data are not cited in this report, but have been used as part of the related backing crash "problem definition/countermeasure technology assessment" program described in Chapter 1.

A.1.5 Tri-Level Study of the Causes of Traffic Accidents

The Indiana Tri-Level Study (Treat et al, 1979a), was an in-depth study of crash causes conducted in the late 1970s by Indiana University. The term "Tri-Level" referred to the collection of three qualitatively-different types of data: mass data (e.g., driver license data including past violations), on-scene crash data (e.g., driver interviews, photography of skidmarks and vehicle final rest positions), and follow-up reconstructions, which included a consideration of human, vehicle, and environmental factors contributing to the crash. Although the study sample size was small (i.e., 420 in-depth cases) and geographically limited (i.e., rural Indiana), it employed an elaborate and insightful taxonomy of crash causal factors. The recent addition of CARDfile accident type codes to the Indiana sample by NHTSA has made it possible to use the Tri-Level findings on causal factors in conjunction with CARDfile and other databases. In this report, the Tri-Level data will not be used to quantify problem sizes, but will be used to provide insights on causes of crash types. Applicable statistics from the Tri-Level Study are cited in the narrative text of this report; detailed statistical summaries from the study have been prepared as separate documents.

A.1.6 FHWA Statistics on Vehicle Registrations and Vehicle Miles Traveled

Statistics on vehicle registrations and vehicle miles traveled (VMT) were obtained from the Federal Highway Administration (FHWA) publication Highway Statistics 1990 (FHWA-PL-91-003). Table VM-1 (Page 192) of this publication provides summary statistics on registrations and VMT by vehicle type. Registration statistics are used to calculate annual likelihoods of involvement and probabilities of involvement over vehicle life. VMT statistics are used to calculate rates of crash involvement.

A.2 Statistical Measures of Problem Size

Target crash problem size assessments are intended to estimate the total number of crashes, fatalities, injuries, and delay hours resulting from target crashes. This includes all fatalities/injuries sustained in all vehicles (and non-vehicles) involved in the target crash. For example, for "combination-unit truck backing crashes", the combination-unit truck was backing, but the fatality/injury counts include both the occupants of the truck ***and*** any other involved vehicles and non-motorists (e.g., pedestrians).

For most target crash types, problem size estimates are provided for three vehicle type categories: all vehicle types combined, passenger vehicles (automobiles, light trucks, vans), and combination-unit trucks. In addition, for backing crashes problem size statistics are provided for medium-heavy single-unit trucks. The following statistical measures of problem size are derived and reported in the problem size assessments:

1. Annual Number of Police-Reported (PR) Target Crashes — *Accessed from datafile (GES, NASS, etc.)*

- **Injury Crashes** — *Includes fatal crashes*
- **Property-Damage Only (PDO)** — *Includes crashes of unknown severity*

Explanation: PR crashes in this report refers to those crashes actually occurred on public roadways and have been automated to the state accident data base. Therefore, police-reported but never been investigated or automated crashes (e.g. private driveway backing crashes killed nonoccupants.) were excluded. The annual number of PR crashes is estimated from one of several crash datafiles. The selection of which datafile to use depends primarily on the "match" between coded data element definitions and the target crash type under consideration. For backing crashes, the estimate is from the 1990 GES. As noted, GES estimates have an associated standard error of estimate. These are provided for major statistical'estimates (e.g., total number of target crashes), and the reader may determine the approximate standard error for any GES estimate contained in this report by using the tables in Appendix D.

2. Annual Number of Fatalities — *Accessed from datafile (generally FARS)*

Explanation: FARS statistics are preferred, since FARS provides a count of fatalities, as opposed to an estimate. FARS statistics are used for the backing analysis. When FARS statistics are not available (i.e., FARS does not code the variable of interest), GES, CARDfile, state, or other data are used to generate a national estimate of the number of fatalities. The fatalities estimate includes fatalities occurring in all vehicles, pedestrians, and pedalcyclists involved in target crashes. Again, FARS statistics do not include off-roadway fatalities. Therefore, the fatality count in FARS is smaller than actual accident fatalities. Especially for those crash types, such as backing crashes, that a relatively high percentage of fatalities occurred on private roadways. However, due to lack of sufficient off-roadway nonoccupant fatality information and the complexity of state-by-state accident data system, non-automated off-roadway fatalities (e.g., nonoccupants were killed on private driveway in backing crashes) ***were*** not included in this report.

3. Annual Number of (Non-Fatal) Injuries in PR Crashes — *Accessed from datafile (GES, CARDfile, etc.); Sum = A+B + C or MAIS 5+4+3+2+1*

- **KABCO Scheme:** — *Severity scheme used in most datafiles*
  - **Incapacitating Injury (A)**
  - **Nonincapacitating Injury (B)**
  - **Possible Injury (C); includes "injured, unknown severity"**
  - **No Injury (0); includes other unknowns**

- ***MAIS*** — *Severity scheme used in NASS CSS and CDS*
  - **Critical (MAIS 5)**
  - **Severe (MAIS 4)**
  - **Serious (MAIS 3)**
  - **Moderate (MAIS 2)**
  - **Minor (MAIS 1)**
  - **No Injury (MAIS 0); includes unknowns**

Explanation: For backing crashes, injuries are assessed based on GES data. Totals include all non-fatal injuries (i.e., A+B+ C injuries in GES) resulting from target crashes (all involved vehicles/non-vehicles). As noted previously, GES estimates have an associated standard error of estimate. These are provided for major statistical estimates (e.g., total number of injuries), and the reader may determine the approximate standard error for any GES estimate contained in this report by using the tables in Appendix C.

4. Annual Total Fatal Crash Equivalents (FCEs) — ***Total Fatal Crash Equivalents (per GES crash severity), whereby fatal crashes are assigned a value of 1.0, and non-fatal crashes are assigned relative severity values between 0 and 1.***

Explanation "Harm" is an abstract concept referring to the total societal loss (e.g., deaths, injuries, property damage) associated with crashes. Here, the statistic "fatal crash equivalent" (FCE), which is similar to Harm, is used to capture total societal loss. FCE is derived from target crash severities. Crash severity is measured in terms of.the most severe police-reported crash injury (the widely-used "KABCO" scheme). The KABCO value is then converted to an FCE value so that crashes of different severities can be measured and assessed on a single ratio scale. Using the FCE scale, two different crash types (e.g., a high severity/low frequency type with a low. severity/high frequency type) can be compared directly in terms of their total effect on society.

Table A-l (based on Miller, 1991) shows how the "fatal crash equivalent" scale is derived from police-reported crash severity ('KABCO"). Note that the use of FCEs cancels out the dollar values so that only relative values assigned to crashes of various severities are factored into the severity reduction calculations. Note also the sharply increasing "Willingness to Pay" value of crashes with increasing JSABCO severity, and thus the sharply increasing FCE value. For example, in the analysis, one 'A" crash will carry the same weight as approximately nine "C' crashes. Thus, the more severe crashes will tend to "drive" the cumulative "fatal crash equivalents" values.

For consistency, unless otherwise noted, the coded GES crash severity is used to determine total FCEs for all crashes and for all crash types.

TABLE A-1: CONVERSION TABLE FOR DERIVING "FATAL CRASH EQUIVALENTS" FROM POLICE-REPORTED CRASH SEVERITY (from Miller, 1991)

"FATAL EQUIVALENTS" CRASH SEVERITY SCALE		
Crash Severity (Most severely-injured occupant, KABCO)	**Comprehensive $ Value Per Crash (1988 Dollars, 4% Discount Rate)**	**Fatal Crash Equivalent ("FCE")**
Fatality (K,4)	$2,722,548	1.0000
Incapacitating (A,3)	$228,568	0.0840
Non-incapacitating (B,2)	$48,333	0.0178
Possible (C,1)	$25,228	0.0093
No Injury (O,0)	$4,489	0.0016
Unreported	$4,144	0.0015

5. Percentage of All Police-Reported (PR) Crashes — *Percentage of the total number of crashes (for subject vehicle type) represented by this crash type*

Percentage of All Crash FCEs — *Percentage of the total crash fatal crash equivalents for subject vehicle type represented by this crash type*

Percentage of All Crash Fatalities — *Percentage of all crash fatalities (involving subject vehicle type) represented by this crash type*

Explanation: Relates this crash type to the overall traffic crash problem for the vehicle type in question. Comparison of the three percentages provides one measure of crash severity relative to crashes in general. For example, backing crashes account for a low percentage of PR crashes, and a relatively low percentage of FCEs and fatalities.

Crashes are assigned FCE values with regard to severity (most severely injured person) only and regardless of the number of vehicles involved, crash type, or vehicle type. Thus the measure may be somewhat unreliable for "exceptional" crash types such as single vehicle crashes and combination-unit truck crashes.

6. Involvement Rate Per 100 Million Vehicle Miles Traveled — *Calculated from target PR crashes and VMT*

Explanation: Involvement rates per 100 million vehicle miles traveled are calculated from annual target crash estimates and annual VMT estimates (see **Table A-2** below). When the problem is defined for a particular vehicle role (e.g., backing vehicle in a backing crash), the involvement rate is based on involvements *in that role only*. It may then be termed the **subject vehicle**; i.e., the crash-involved vehicle that, if equipped with the countermeasure, could potentially have avoided the crash. Other involvement rates provided do not specify a vehicle role; these include involvements in all crashes and involvements in some specific crash type regardless of role. For each involvement rate provided, this report will specify whether the rate is based on "subject vehicle involvements only" or "all involvements." Note that the passenger vehicle mileage data in Table A-2 includes both passenger cars ***and 2-axle,*** 4-tire single-unit trucks (i.e., pickup and vans). The single-unit truck data shown does not include 2-axle, Ctire trucks and thus corresponds to the "Other Single-Unit Trucks" column of Table VM-1 of Highway ***Statistics.***

TABLE A-2: 1989 AND 1990 VEHICLE MILES TRAVELED (IN MILLIONS) FOR VARIOUS VEHICLE CATEGORIES (Source: *Highway Statistics, 1990,* FHWA, Table VM-1)

ANNUAL VEHICLE MILES TRAVELED (VMT, in millions)		
Vehicle Category:	**1989**	**1990**
Ail Vehicle Types	**2,107,040**	2,147,501
Passenger Vehicles	1.942.173	1.982.197
Combination-Unit Trucks	**95,567**	**96,482**
Single-Unit Trucks	**53,190**	53,522

Average annual miles traveled per vehicle in 1990 were as follows for these four vehicle type categories:

- All vehicle types: 11,132 miles
- Passenger vehicles: 10,879 miles
- Combination-unit trucks: 60,032 miles
- Single-unit trucks: 12,683 miles.

7. Annual "Likelihood" of Involvement (Annual Involvements Per 1,000 Vehicles)

Calculated from target PR crashes and vehicle registrations

Explanation: This statistic provides a useful annual perspective on "likelihood" of involvement in target crashes (as the subject vehicle). It is determined by the following formula:

$$\text{Annual Involvements Per 1,000 Vehicles} = \frac{1{,}000 \text{ X Target Crashes}}{\text{\# Registered Vehicles}}$$

Like involvement rate per 100 million VMT, this statistic may be calculated based on all involvements (e.g., all crashes, all involvements in some crash type) or based upon a particular vehicle role in the crash (e.g., backing vehicle in a backing crash). Note that the passenger vehicle registration data in Table A-3 includes both passenger cars ***and*** 2-axle, 4-tire single-unit trucks (i.e., pickup and vans). The single-unit truck data shown does not include 2-axle, Ctire trucks and thus corresponds to the "Other Single-Unit Trucks" column of Table VM-1 of Highway ***Statistics.***

TABLE A-3: 1989 AND 1990 VEHICLE REGISTRATIONS FOR VARIOUS VEHICLE CATEGORIES (Source: ***Highway Statistics, 1990,*** **FHWA, Table VM-l)**

VEHICLE REGISTRATIONS		
Vehicle Category:	**1989**	**1990**
All Vehicle Types	**191,694,462**	**192,914,924**
Passenger Vehicles	**185,366,849**	**182,201,372**
Combination-Unit Trucks	**1,589,285**	**1,607,183**
Single-Unit Trucks	4,102,863	4,219,920

8. Expected Number of Involvements During Vehicle Life

Calculated from target PR crashes, vehicle registrations, and average vehicle life

Explanation: The expected number of crash subtype involvements during the vehicle life is determined by the following formula:

$$\textbf{Expected Number .} = \frac{\text{Annual Involvements in Target Crashes X Average Vehicle Life}}{\text{\# Registered Vehicles}}$$

Like the previous two statistics, this statistic may be calculated based on all involvements (e.g., all crashes, all involvements in a specific crash type) or based upon a particular vehicle role in the crash (e.g., backing vehicle in a backing crash). For specific crash types (and especially for specific vehicle roles in specific crash types), this value is typically low, i.e., less than 0.2. For such low values, the statistic can be treated as an approximate probability estimate **to** answer the question, "What is the probability that a vehicle will "need" the subject countermeasure during its life?" This statistic can also be used to derive per-vehicle-produced target crash "value" (average crash value times expected number during vehicle life).

Statistical constants used to make these calculations include the following:

- Vehicle registrations: same values as used above (Item 7)
- Vehicle life, all vehicle types combined: 13.13 years. This value was derived from Miaou (1990) based on a weighted average of the average operational lives of passenger cars (11.77 years) and "all trucks" (15.84 years). The relative weights for calculating the weighted mean were based on 5-year averages (1987-91) of U.S. retail sales for these two vehicle categories (MVMA, 1992).
- Vehicle life, passenger vehicles: 13.01 years. This value was derived from Miaou (1990) based on a weighted average of the average operational lives of passenger cars (11.77 years) and light trucks (16.05 years). The relative weights for calculating the weighted mean were based on S-year averages (1987-91) of U.S. retail vehicle sales for these two vehicle categories (MVMA, 1992).
- Vehicle life, medium/heavy trucks (both combination-unit and single-unit): 14.70 years (Miaou, 1990). Miaou's data did not separate combination-unit and single-unit trucks. A possible future refinement of this analysis would employ separate life values for these two vehicle types.

Note also that Miaou's estimated vehicle life values are based on analyses of the registration period from 1978 to 1988 (or 1989). Miaou's data show a trend toward longer vehicle lives for more recent time periods (e.g., 1978-88 versus 1966-73). If this trend continues, vehicles purchased now and in the coming decade will have somewhat longer operational lives than the values used here. A trend toward longer vehicle life is corroborated by R. L. Polk and Company data, cited in Davis and Morris (1992), showing that the average age of both automobiles and trucks in use has increased steadily over the past ***20 years.***

9. Estimated Annual Number of Non-Police-Reported (NPR) Target Crashes	***Estimated per algorithm described below***
• Injury Crashes	***Estimated to be 11.8% of NPR target crashes***
• Property-Damage Only (PDO)	***Estimated to be 88.2% of NPR target crashes***

Explanation: The estimate of Non-Police Reported (NPR) crashes is based on the known number of PR PDO crashes and the estimated total number of NPR crashes nationally. Specifically, the following equation is used to estimate target NPR crashes:

$$\text{Target NPR Crashes} = \frac{\text{Target PR PDO Crashes X All NPR Crashes}}{\text{All PR PDO Crashes}}$$

Statistical constants used to make these calculations include the following:
- All NPR crashes, all vehicle types: 7.77 million (Miller, 1991)
- All NPR crashes, passenger vehicles: 7.66 million (estimated from Miller, 1991, and proportion of passenger vehicle involvements in PR PDO crashes).
- All NPR crashes, combination-unit trucks: 0.29 million (estimated from Miller, 1991, and proportion of combination-unit truck involvements in PR PDO crashes).
- All NPR crashes, single-unit trucks: 0.19 million (estimated from Miller, 1991, and proportion of single-unit truck involvements in PR PDO crashes).
- Percentage of NPR crashes with injuries: 11.8 percent (Greenblatt et al, 1981; same value used for all vehicle type categories).

NPR crash problem size estimations resulting from the above algorithm should not be accepted uncritically. The algorithm assumes proportionality between NPR crashes and PR PDO crashes, which are generally more severe than NPR crashes. The algorithm likely overestimates NPR crashes for crash types that are often serious and thus not likely to go unreported. Examples include head-on crashes and rollovers. On the other hand, the algorithm likely underestimates NPR crashes for crash types that are usually minor in severity and thus less likely to be reported. Examples include rear-end crashes and backing crashes. As this program progresses, it may be possible to develop a more sophisticated NPR crash estimation algorithm or to incorporate fmclmgs from other sources (e.g., insurance claim data) to better estimate NPR crashes.

Miller (1991) estimated the average comprehensive value of unreported crashes to be $4,144, corresponding to a fatal crash equivalent ("FCE") value of 0.0015. However, the FCE associated with NPR crashes is not incorporated into the FCE estimates of this report.

10 Estimated Total Annual Target Crashes	***Total target crashes (UDH + Non-UDH)***
• **Urban-Divided Highway (UDH)**	***Total PR + NPR***
- **PR**	***Accessed from datafile***
- **NPR**	***Estimated based on PR UDH target crashes***
• **Non-Urban Divided Highway**	***Total PR + NPR***
- **PR**	***Accessed from datafie***
- NPR	***Estimated based on PR Non-UDH target crashes***

Explanation: The UDH/non-UDH breakout is used to estimate delay caused by target crashes (see item #11 below). Target UDH NPR values are estimated from PR values as follows:

$$\text{Target UDH NPR Crashes} = \frac{\text{Target UDH PR Crashes X Target NPR Crashes}}{\text{Target PR Crashes}}$$

GES classifies its geographic Primary Sampling Units (PSUs) using a "Percent Rural" scale based on 1980 U.S. Census data (not Federal Roadway classification). In GES there are 11 urban/rural categories: Urban, 10 percent Rural, 20 percent Rural, etc. Within a PSU that is part urban and part rural, specific crashes cannot be identified as "urban" or "rural." Disaggregated "urban" and "rural" crash estimates are obtained by an imputation process, as follows (Note: this is a rough estimates):

- 0% of "Urban" crashes are counted as "rural."
- 10% of "10% of Area is Rural" crashes are counted as "rural."
- **20%** of "20% of Area is Rural" crashes are counted as "rural."; etc.

This tabulation is performed separately for divided highway and "other" crashes to obtain two estimates for PR crashes: UDH and Non-UDH (i.e., all other). Then the NPR estimates are generated based on the PR estimates.

The PR and NPR breakouts for UDH and Non-UDH crashes are not shown in the crash problem size tables, but are used to estimate vehicle-hours of delay (see below).

The urban vs. rural disaggregation provided by the GES "Percent Rural" variable should be regarded as a rough estimate. Since this variable is determined at the GES PSU level,. standard errors for these estimates are based on a sample size of 60 (the number of PSUs) not 45,000 (the number of crashes). The'resulting relative errors for these estimates (standards error divided by the estimate) range from 3 to 5 times as great as the relative errors given in Appendix D.

11. Estimated Annual Vehicle-Hours of Crash-Caused Delay	***Estimated from calculations based on UDH vs. Non-UDH breakout***
Percent of All Crash-Caused Delay	***Delay caused by the target crash type as a percentage of all crash-caused delay (estimated here as 460.2 million vehicle hours for 1990).***

Explanation: Crash-caused congestion (delay) is strongly related to crash location and severity. In particular, UDH crashes cause far greater delay per crash than do non-UDH crashes. The following formula is used to estimate total vehicle-hours of delay caused by target crashes:

Total Vehicle-Hours Delay =		300	X	PR UDH Target Crashes
	+	100	X	NPR UDH Target Crashes
	+	5	X	PR Non-UDH Target Crashes
	+	1	X	NPR Non-UDH Target Crashes

The above co-efficients are working estimates based on several studies; e.g., Cambridge Systematics, 1990; Grenzeback et al, 1990. Using the above algorithm, the annual total crash-caused vehicle-hours of delay is estimated to be 460.2 million vehicle-hours for 1990. This value is used to calculate percentages of total crash-caused delay for specific crash types, including those for specific vehicle types. This percentage is intended to provide a sense of how much prevention of this crash type would affect crash-caused roadway congestion.

Crash-caused delay estimations resulting from the above algorithm should not be accepted uncritically. The algorithm assumes that delay is a function of just two factors: crash location and crash severity. Other relevant factors (e.g., involved vehicle types, time of crash, weather conditions) are not incorporated at this time. Moreover, certain crash types are likely to cause greater lane blockage or more lengthy delays due to vehicle extrication efforts than other crashes of the location and severity. For example, head-on crashes are likely to block multiple lanes, and rollover crashes are likely to require extra time for vehicle extrication. As this program progresses, it may be possible to develop a more sophisticated delay estimation algorithm to account for some of these additional factors.

A planned upgrade to the delay estimation algorithm is to use larger average delay values for crashes involving heavy trucks. Currently, this document uses the same delay values for heavy trucks as for other vehicle types. This is known to yield an underestimate of delay caused by truck crashes. Bowman and Hummer (1989) estimated the average delay caused by truck urban freeway crashes to be 914 vehicle-hours. They cited a study by Teal (1988) that estimated the value to be 1,179 vehicle-hours. The median estimate of these two studies is approximately 1,000 hours. Extending the urban freeway truck-car difference to all vehicle types, a better formula for estimating delay caused by truck crashes might be:

Total Vehicle-Hours Delay =		1,000	X	PR UDH Target Crashes
(Heavy Truck Crashes)	+	300	X	NPR UDH Target Crashes
	+	15	X	PR Non-UDH Target Crashes
	+	3	X	NPR Non-UDH Target Crashes

The above formula is likely to be more accurate for heavy truck crashes. Nevertheless, for simplicity, at present the **same delay estimation formula is used for all vehicle type categories.**

A.3 Descriptive Statistics

In addition to problem size assessment statistics, this document provides descriptive statistics relating to crash incidence. These are primarily univariate and bivariate (e.g., vehicle type category by other factor) distributions that characterize the component "subtypes" of the target crash type, conditions under which target crashes occur, and, when possible, statistics providing insights into the primary causes of crashes. The national crash databases described in Section A.2 provide very informative data on crash conditions and characteristics, but generally do not specify crash causes with sufficient precision and reliability to permit the identification of appropriate countermeasures or the estimation of countermeasure effectiveness. One important study, the Indiana Tri-Level Study (Treat et al, 1979a; see Section A.1.6), does provide insightful data on crash causes, but is based on only 420 in-depth crashes occurring in rural Indiana. Its representativeness to current national crash problems is thus questionable. However, Indiana Tri-Level statistics are provided when there were a sufficient number of target crash cases to provide meaningful information on crash causes.

A.4 Definitions of Vehicle Types

For most backing crash data retrievals (including the backing retrievals), three vehicle type categories are used:

- All vehicle types (combined)
- Passenger vehicles (automobiles, light trucks, light vans)
- Combination-unit trucks (generally tractor trailers or "bobtail" tractors)

In addition, for selected topics, crash data retrievals are presented for medium/heavy single-unit (straight) trucks.

In GES and FARS, discriminating combination-unit trucks from single-unit trucks (and both from light trucks) requires the use of two different vehicle variables: body type and vehicle trailering. The category "combination-unit truck" is considered to include all tractors (whether pulling a trailer or running bobtail) as well as other medium-heavy trucks that are known to be pulling a trailer. This includes-a small number of trucks with single-unit designs that were in fact pulling a trailer at the time of the crash.

GES and FARS use the same element numbering scheme for the "trailering" variable (TRAILER in GES; TOW VEH in FARS). The scheme is: 0 = no trailer; 1 = 1 trailer; 2 = 2 trailers; 3 = 3 or more trailers; 4 = pulling trailer(s), number unknown; 9 = unknown if pulling trailer.

Moreover, in GES there are a significant number of vehicles with unknown or partially-unknown body types (i.e. 49 = unknown light vehicle type; 69 = unknown truck type; and 99 = unknown body type). In the 1990 GES, for example, these totaled 6.4 percent of vehicles. This means that statistics on individual vehicle body types will underestimate involved vehicles of that type to the extent that vehicles of that type were coded as *"unknown."* To correct for this effect, GES problem size statistics for specific body types use the GES variable Hotdeck Imputed Body Type (V51, BDYTYP_H). In the imputed body type variable, vehicles of unknown body type are distributed proportionately across the known body types, thus correcting, as accurately as possible, the problem of the unknown vehicle types.

The vehicle type unknown rate in FARS is low and has no significant impact on crash counts; thus, there are no "imputed" vehicle types in FARS.

Below is a summary of the definitions used and relevant caveats. For each GES statistic, the Hotdeck Imputed Body Type (V5I, BDYTYP_H) variable is used for problem size assessment and the descriptive statistics.

GES Passenger Vehicle (Car/Lt.Trk/Van):

01 ≤ Body Type ≤ 49

GES Combination-Unit Truck:

Body Type = 60 (single-unit straight truck) & 1 ≤ TRAILER ≤ 4
Body Type = 65 (truck-tractor, cab only or any number of trailers)
Body Type = 68 (unknown medium/heavy truck) & 1 ≤ TRAILER ≤ 4
Body Type = 69 (unknown truck type) & 1 ≤ TRAILER ≤ 4

GES Single-Unit Truck:

Body Type = 60 (single-unit straight truck) & TRAILER = 0 or 9 (unknown)
Body Type = 68 (unknown medium/heavy truck) & TRAILER = 0 or 9 (unknown)

FARS Passenger Vehicle (Car/Lt.Trk/Van):

01 ≤ Body Type ≤ 14, or
40 ≤ Body Type ≤ 69

FARS Combination-Unit Truck:

Body Type = 70 (single-unit straight truck, GVWR 10,000-19,500) & 1 ≤ TOW_VEH ≤ 4
Body Type = 71 (single-unit straight truck, GVWR 19,500-26,000) & 1 ≤ TOW_VEH ≤ 4
Body Type = 72 (single-unit straight truck, GVWR over 26,000) & 1 ≤ TOW_VEH ≤ 4
Body Type = 74 (truck-tractor; cab only or any number of trailers)
Body Type = 75 (unknown medium truck) & 1 ≤ TOW_VEH ≤ 4
Body Type = 76 (unknown heavy truck) & TOW_VEH > 0
Body Type = 78 (single-unit straight truck, GVWR unknown) & 1 ≤ TOW_VEH ≤ 4
Body Type = 79 (unknown truck type) & 1 ≤ TOW_VEH ≤ 4

FARS Single-Unit Truck:

Body Type = 70 (single-unit straight truck, GVWR 10,000-19,500) & TOW_VEH = 0 or 9
Body Type = 71 (single-unit straight truck, GVWR 19,500-26,000) & TOW_VEH = 0 or 9
Body Type = 72 (single-unit straight truck, GVWR over 26,000) & TOW_VEH = 0 or 9
Body Type = 75 (unknown medium truck) & TOW_VEH = 0 or 9
Body Type = 76 (unknown heavy truck) & TOW_VEH = 0
Body Type = 78 (single-unit straight truck, GVWR unknown) & TOW_VEH = 0 or 9

APPENDIX B: PROBLEM SIZE ASSESSMENT: ALL CRASHES

This appendix presents crash problem size assessment statistics for the "universe" of crashes. Primary estimates are provided based largely on 1990 GES and FARS data.

For each data source, estimates are provided for all vehicle types, crashes involving passenger vehicles (automobiles, light trucks, vans), and crashes involving combination-unit trucks. Note that the passenger vehicle and combination-unit truck crash and injury counts do not sum to equal the "all vehicles" values. Some vehicle types (i.e., medium/heavy single-unit trucks, motorcycles, buses) are included in "all vehicles" but not either of the other two columns. Also, a crash (or injury/fatality occurring in a crash) involving both a passenger vehicle and a combination-unit truck would be counted in ***both*** columns, but only once in the "all vehicles" column. This "double counting" would extend to the rate and likelihood statistics; a passenger vehicle/combination-unit truck crash would be counted in the numerators of both columns, but the associated denominators (VMT and registrations) would reflect only passenger vehicles and combination-unit trucks.

Appendix A described in detail the target crash problem size statistics used in this report and how they are derived. **Table B-l** summarizes key 1989 and 1990 statistical findings and associated estimates derived as described in Appendix A. Table B-l indicates that, overall police-reported crashes, fatalities and non-fatal injuries decreased between 1989 and 1990. However, urban-divided highway crashes (per the GES "Percent Rural" variable) increased in 1990. Table B-l also reveals that even though police-reported crashes and fatalities experienced a decrease in 1990, the estimated crash-caused hours of delay were greater in 1990 (The difference is about 18 million hours). **Table B-2** provides more detailed 1990 statistics for all vehicles, passenger vehicles, and combination-unit trucks.

Standard errors of estimate for 1990 GES-based statistics may be derived through interpolation of the values presented in the tables contained in Appendix A.

TABLE B-l: SUMMARY OF KEY STATISTICS AND ASSOCIATED ESTIMATES FOR ALL CRASHES, ALL VEHICLE TYPES

Statistic	1989	1990
Police-Reported Crashes (GES)	6.64 million	6.46 million
Vehicles Involved in Police-Reported Crashes (GES)	11.56 million	11.3 million
Fatalities (FARS)	45,582	44,599
Non-Fatal Injuries in PR Crashes (GES)	3.28 million	3.23 million
Non-Police Reported Crashes (Miller, 1991)	7.77 million*	7.77 million*
Urban Divided Highway Crashes (PR+NPR; see Chpt 2 for Estimation Method)	2.11 million	2.23 million
Crash-Caused Vehicle-Hours Delay (PR+NPR; see Chpt 2 for Estimation Method)	442.0 million hours	460.2 million hours

* Same estimate used for 1989 and 1990 NPR crashes (from Miller, 1991)

In this appendix presenting statistics on all crash types combined, the involvement rate and "likelihood" statistics (i.e., involvement rate per 100 million VMT, annual involvements per 1,000 vehicles, and expected number of involvements over vehicle life) are based on all crash involvements, regardless of vehicle role. Note, however, that in the report chapters on backing crashes, involvement statistics are based on subject vehicle (e.g., backing vehicle) involvements only. For any crash type, the **subject vehicle** is the crash-involved vehicle that, if equipped with the countermeasure, could potentially have prevented the crash (see Section A.2 Item 5). However, since the subject vehicle cannot be defined for all crash types combined, the involvement statistics in Table B-2 are based on all involvements, regardless of the vehicle's role.

. In comparing the crash experiences of the different vehicle types shown in Table B-2, the most revealing statistics are those that contrast the passenger vehicle crash experience with that of combination-unit trucks. In 1990, Combination-unit truck had a crash involvement ***rate*** (per 100 million vehicle miles traveled) that was 45 percent of the passenger vehicle rate. In contrast, their ***likelihood*** of involvement in crashes (as shown by statistics on annual involvements per 1,000 vehicles and expected number of involvements during vehicle life) was 274 percent of the passenger vehicle likelihood.

TABLE B-2
PROBLEM SIZE ESTIMATE: ALL CRASHES
INVOLVED VEHICLE TYPES: ALL VEHICLES, PASSENGER VEHICLES, COMBINATION-UNIT TRUCKS

GES/FARS-Based Statistics (1990)

		All Vehicles	Combination- Vehicles	Passenger Unit Trucks
Annual# PR Crashes (GES)	Total:	6,462,000	6,299,000	223,000
	Injury:	2,153,000	2,092,000	62,000
	PDO:	4,309,000	4,207,000	161,000
Annual # Fatalities (FARS)		44,599	40,829	4,217
Ann. # Non-Fatal PR Injuries (GES)	Total:	3,231,000	3,144,000	85,000
	A:	478,000	457,000	16,000
	B:	942,000	908,000	24,000
	C:	1,812,000	1,779,000	46,000
Fatal Crash Equivalents (FCEs)		89,907	86,203	4,883
Involvement Rate Per 100 Million VMT		526.9	542.3	237.9
Annual Involvements Per 1,000 Registered Vehicles		58.65	58.99	142.83
Expected # Involvements During Vehicle Life		0.7701	0.7675	2.0996
Estimated Annual # NPR Crashes	Total:	7,770,000	7,586,000	291,000
	Injury:	917,000	895,000	34,000
	PDO:	6,853,000	6,691,000	256,000
Estimated Total Annual Crashes (PR + NPR)	Total:	14,232,000	13,885,000	514,000
	UDH:	2,235,000	2,188,000	155,000
	Non-UDH:	11,997,000	11,696,000	359,000
Crash-Caused Congestion (Delay)	Veh-Hours:	460.2 M	450.3 M	29.8 M

Legend:

A	Incapacitating Injuries
B	Nonincapacitating Injuries
C	Possible Injuries
FARS	Fatal Accident Reporting System
FCE	Fatal Crash Equivalent
GES	General Estimates System
M	Million
NPR	Non-Police Reported
PDO	Property Damage Only
PR	Police Reported
UDH	Urban Divided Highway
VMT	Vehicle Miles Traveled

This apparent paradox is due to the much greater crash ***exposure*** of trucks; i.e., their average annual vehicle miles traveled is approximately six times that of passenger vehicles. In addition, combination-unit truck crashes are more likely to be severe; in 1990 there were approximately 18.9 fatalities per 1,000 police-reported truck crashes, versus approximately 6.5 fatalities per 1,000 police-reported passenger vehicle crashes. The greater likelihood of truck involvement in crashes, together with the greater average severity of these crashes, makes combination-unit trucks an attractive test bed for crash avoidance countermeasures.

The statistic "Fatal Crash Equivalents" (FCEs) was defined in Appendix A (e.g. Table A-l). The value of 89,907 FCEs shown in Table B-2 for all vehicles was derived from statistics on 1990 GES crash severity (fatal and various levels of non-fatal crashes) to as shown in Table B-3.. Final value of total FCEs is rounded to nearest unit.

TABLE B-3: FATAL CRASH EQUIVALENTS (FCEs) FOR ALL CRASHES, ALL VEHICLE TYPES

"FATAL CRASH EQUIVALENT"			
Crash **Severity.**	**# of Crashes**	**FCE Value**	**Total FCEs**
Fatality (K, 4)	**30,760**	**1.0000**	**30,760**
Incapacitating (A, 3)	**359,491**	**0.0840**	**30,197**
Non-incapacitating (B, 2)	**666,337**	**0.0178**	**11,861**
Possible Injury (C, 1)	**1,096,092**	**0.0093**	**10,194**
No injury (0, 0)	**4,309,446**	**0.0016**	**6,895**
All1 **Crashes, All Vehicles**	**6,462,126**		**89,907**

As noted in Appendix A, the statistics provided for non-police-reported (NPR) crashes, urban divided highway crashes (PR+NRR) and crash-caused delay are based on new estimation techniques that have not been verified. Thus, they should be regarded as very rough estimates. Although these statistics are rough, they will be useful in comparing difficult-to-quantify aspects of the various crash types; **i.e.,** the proportion of NPR crashes they represent and crash-caused traffic delay they cause.

In addition to the problem size assessment statistics presented in this appendix, various descriptive statistics of "all crashes" were derived and considered in relation to the backing crash statistics. A presentation of these statistics for "all crashes" is beyond the scope of this report. The reader is referred to the GES and FARS annual reports.

APPENDIX C: DATA SPECIFICATIONS

This appendix provides detailed data specifications of the backing crash subtypes per the GES and FAR data files. Note that the terms "parallel path," "curved path," and "crossing-path" used in this report to describe backing crash subtypes are intended to capture the ***predominant*** vehicle movements and scenarios associated with these subtypes. However, these vehicle movements are not the basis for the data specifications since such descriptions of the pre-crash path (e.g., straight versus curved) are not contained in GES or FARS. The terms "parallel path, "curved path," and "crossing-path" arose from examinations of individual backing crash case files conducted by Tijerina ***et al (1993)*** as part of the related countermeasure assessment program and are used here in order to maintain consistency with that analysis.

C.1 Backing Crash Types/Subtypes

Backing crash types/subtypes were defined as follows in GES and FARS:

GES Estimates (1990) (Note: The reader is referred to the 1990 GES User's Manual for definition and explanation of the following data variables.):

1. <u>Encroachment Backing Crashes</u>

l a . Pedestrian/pedalcyclist

Crashes involving vehicle with Accident Type (V23, ACC_TYPE) 92 with criteria:

- Imputed Vehicle Role (V22I, VROLE_I) **= 01** (Striking)
- Hotdeck Imputed Vehicle Most Harmful Event (V20I, V_EVNT_H)
  = 21 (Pedestrian)
  = 22 (Pedalcyclist)

lb. Parallel path, vehicle

Crashes involving Accident Type 92 and 93, where the vehicle with Accident Type 92 meets the following criteria:

- Imputed Vehicle Role (V22I, VROLE-I) = 01 (Striking) and, for the vehicle with Accident Type 93:

- Vehicle Speed (Vll, SPEED) < 05 (Stopped or Slowly Moving)

- Hotdeck Imputed Initial Point of Impact (V24I, IMPACT_H)
  = 0 (No Damage)
  = 1 (Front)

lc. Curved path, stationary vehicle or object

Backing into stationary vehicle; crashes involving Accident Type 92 and 93, where vehicle with the Accident Type 92 meets the following criteria:

- Imputed Vehicle Role (V22I, VROLE-I) = 01 (Striking)

and, for the struck vehicle with Accident Type 93:

- Vehicle Speed (Vll, SPEED) = 00 (Stopped)

- Hotdeck Imputed Initial Point of Impact (V24I, IMPACT-H)
  = 2 (Rightside)
  = 3 (Leftside)
  = 4 (Back)
  = 7 (Corner)

Or: backing into fixed objects; crashes involving vehicles with Accident Type 92 meeting the following criteria:

a Hotdeck Imputed Vehicle Most Harmful Event (V20I, V_EVNT_H)
  = 31 - 49 (Collision with Fixed Object)

- Imputed Vehicle Role (V22I, VROLE-I) = 01 (Striking)

2. **<u>Crossing Path Backing Crashes</u>**

Backing vehicle strikes front of a moving vehicle; i.e., crashes involving Accident Types 92 and 93 where the vehicle with Accident Type 92 meets the following criteria:

- Imputed Vehicle Role (V22I, VROLE-I) = 01 (Striking)

and, for the vehicle with Accident Type 93:

- Hotdeck Imputed Initial Point of Impact (V24I, IMPACT-H)
  = 0 (No Damage)
  = 1 (Front)

- Vehicle Speed (Vll, SPEED) > 06 (Moving; Includes Unknowns)

Or: backing vehicle strikes other part of moving vehicle; i.e., crashes involving Accident Types 92 and 93, where the vehicle with Accident Type 92 meets the following criteria:

- Imputed Vehicle Role (V22I, VROLE-I) = 01 (Striking)

and, for the vehicle with Accident Type 93:

- Hotdeck Imputed Initial Point of Impact (V24I, IMPACT-H)
  = 2 (Rightside)
  = 3 (Leftside)
  = 4 (Back), or
  = 7 (Corner)

- Vehicle Speed (Vll, SPEED) > 01 (Moving; Includes Unknowns)

Or: backing vehicle is struck by moving vehicle; crashes involving Accident Types 92 and 93 where the vehicle with Accident Type 92 meets the following criteria:

- Imputed Vehicle Role (V22I, VROLE_I)
  = 02 (Struck)
  = 03 (Both Striking and Struck)

and, for the vehicle with Accident Type 93:

- Vehicle Speed (Vll, SPEED) > 01 (Moving; Includes Unknowns)

FARS Estimates (1990) (Note: The reader is referred to the 1990 FARS Coding and Validation Manual for definition and explanation of the following data variables.):

1. <u>Encroachment Backing\ Crashes</u>

la. Pedestrian/pedalcyclist

- Vehicle Maneuver (VEH_MAN) = 15 (Backing Up)

- Vehicle Role (IMPACTS) = 01 (Striking)

- Most Harmful Event (HARM_EV) = 8 (Pedestrian)
  = 9 (Pedalcyclist)

1b. Parallel path, vehicle

The striking vehicle meets the following criteria:

- Vehicle Maneuver (VEH_MAN) = 15 (Backing Up)
- Vehicle Role (IMPACTS) = 01 (Striking)

and, for the struck vehicle:

- Vehicle Role (IMPACTS) ≠ 01 (Striking)
- Vehicle Speed (TRAV_SP) ≤ 5 (Stopped or Slowly Moving)
- Point of Initial Impact (IMPACT1) = 00 (No Collision)
= 12 (Front)

1c. Curved path, stationary vehicle or object

The striking vehicle meets the following criteria:

- Vehicle Maneuver (VEH_MAN) = 15 (Backing Up)
- Vehicle Role (IMPACTS) = 01 (Striking)

and, for the struck vehicle:

- Vehicle Role (IMPACTS) ≠ 01 (Striking)
- Vehicle Speed (TRAV_SP) = 0 (Stopped)
- Point of Initial Impact (IMPACT1) = 1 - 11 (Right, Left and Back)

<u>Or</u>: struck object; striking vehicle meets the following criteria:

- Vehicle Maneuver (VEH_MAN) = 15 (Backing Up)
- Vehicle Role (IMPACTS) = 01 (Striking)
- Most Harmful Event (HARM_EV) = 17 - 43 (Fixed Objects)

2. Crossing Path Backing Crashes

Backing vehicle strikes front of a moving vehicle; where striking vehicle meets the following criteria:

- Vehicle Maneuver (VEH_MAN) = 15 (Backing Up)
- Vehicle Role (IMPACTS) = 01 (Striking)

and, for struck vehicle:

- Vehicle Role (IMPACTS) ≠ 01 (Striking)
- Vehicle Speed (TRAV_SP) ≥ 6 (Moving; Includes Unknowns)
- Point of Initial Impact (IMPACT1) = 00 (No Collision)
= 12 (Front)

Or: backing vehicle strikes other part of moving vehicle. Striking vehicle meets the following criteria:

- Vehicle Maneuver (VEH_MAN) = 15 (Backing Up)
- Vehicle Role (IMPACTS) = 01 (Striking)

and, for struck vehicle:

- Vehicle Role (IMPACTS) ≠ 01 (Striking)
- Vehicle Speed (TRAV_SP) ≥ 01 (Moving; Includes Unknowns)
- Point of Initial Impact (IMPACT1) = 1 - 11 (Right, Left and Back)

Or: backing vehicle is struck by moving vehicle. Striking vehicle meets the following criteria:

- Vehicle Maneuver (VEH_MAN) = 15 (Backing Up)
- Vehicle Role (IMPACTS) = 02 (Struck)
= 03 (Both Striking and Struck)

and, for moving vehicle:

- Vehicle Role (IMPACTS) = 01 (Striking)
- Vehicle Speed (TRAV_SP) ≥ 01 (Moving; Includes Unknowns)

C.2 "UC" Backing Crashes

The data specifications described in Section C.1 are applied, with the following *additional* "disqualifiers" applied to the crash or the driver of the backing vehicle:

GES Estimates (1990) (Additional Qualifiers):

- Imputed Roadway Surface Condition (A15I, SURCON_I) ≠ 03 (snow/slush)
  ≠ 04 (ice)
- Vehicle Defects (V12, DEFECT) ≠ 02 (Brake System)
  ≠ 03 (Steering System)
  ≠ 13 (Driver Seating and Control)
  ≠ 15 (Trailer Hitch)
  ≠ 97 (Vehicle Defects-No Detail)
  ≠ 98 (Other Vehicle Defects)
- Imputed Violations Charged (D2I, VLTN_I) ≠ 01 (Alcohol/Drugs)
  ≠ 03 (Alcohol/Drugs and Speeding)
  (Note: the use of this variable is intended to exclude grossly-intoxicated drivers only, as opposed to all alcohol/drug involvement cases.)
- Driver Presence (D1, DR_PRES) ≠ 0 (Driverless, or No Driver Involved)
- Person's Physical Impairment (P18, IMPAIRMT) ≠ 01 (Ill, Blackout)
  ≠ 02 (Drowsy, Sleepy, Fell Asleep, Fatigued)
  ≠ 05 (Impaired Due to Previous Injury)
  ≠ 06 (Deaf).

FARS Estimates (1990) (Additional Qualifiers):

- Roadway Surface Condition (SUR_COND) ≠ 03 (snow/slush)
  ≠ 04 (ice)
- Vehicle Related Factors (VEH_CF1 and VEH_CF2) ≠ 02 (Brake System)
  ≠ 03 (Steering System)
  ≠ 13 (Driver Seating and Control)
  ≠ 15 (Trailer Hitch)
  ≠ 18 (Other Vehicle Defect)

• Violations Charged (VIOL_CHG) (Note: the use of this variable is intended to exclude grossly-intoxicated drivers only, as opposed to all alcohol/drug involvement cases.)	≠ 01 (Alcohol/Drugs) ≠ 03 (Alcohol/Drugs and Speeding)
• Driver Presence (DR_PRES)	≠ 02 (Driverless)
• Related Factors, Driver-Level (DR_CF1, DR_CF2, DR_CF3)	≠ 01 (Drowsy, Sleepy, Fell Asleep, Fatigued) ≠ 02 (Ill, Blackout) ≠ 09 (Impaired Due to Previous Injury) ≠ 10 (Deaf).

APPENDIX D: GENERALIZED ESTIMATED SAMPLING ERRORS FOR 1990 GES

This appendix presents tables for estimating sampling errors for 1990 GES estimates. These tables (and the narrative explanation below) are taken from the "Technical Note for 1988, 1989, 1990 National Accident Sampling System General Estimates System" (DOT HS 807 796, February, 1992).

The General Estimates System (GES) is based on a probability sample of approximately 45,000 motor vehicle police traffic accident reports selected on an annual basis. GES is not a census of all 6.5 million police-reported crashes in the U.S. Consequently, GES estimates are subject to sampling errors, as well as nonsampling errors.

Sampling errors are the differences that can arise between results derived from a sample and those computed from observations of all units in the population being studied. Since GES data are derived from a probability sample, estimates of the sampling error can be made.

The tables provided in this appendix can be used to calculate confidence intervals about the GES estimates. Tables are provided for crash, vehicle, and people (e.g., number of injuries) estimates. The numbers in the tables represent estimates of one standard error. If all possible samples of PARS were selected (under the same conditions), then approximately 68 percent of the intervals from one standard error below the estimate to one standard error above the estimate would include the average of all possible samples. Thus, the interval between one standard error below the estimate and one standard error above the estimate constitutes a 68 percent confidence interval. An interval of two standard errors above and below the estimate is a 95 percent confidence interval.

The best method for calculating standard errors is to use the natural logarithmic function provided for each estimate type. However, linear interpolation may also be used. For example, from the crash (Table D-l) standard error values for 300,000 and 400,000, the standard error for 350,000 is approximated at 25,600. The 68 percent confidence interval for this estimate would be 350,000 $\pm$ 25,600 or 324,400 to 375,600.

TABLE D-1:

1990 CRASH ESTIMATES AND STANDARD ERRORS

Estimate (x)	One Standard Error (SE)*	Estimate (x)	One Standard Error (SE)*
1,000	700	600,000	40,000
5,000	1,400	700,000	45,700
10,000	2,100	800,000	51,200
20,000	3,300	900,000	56,700
30,000	4,200	1,000,000	62,200
40,000	5,100	2,000,000	116,200
50,000	5,900	3,000,000	169,800
60,000	6,800	4,000,000	223,700
70,000	7,500	5,000,000	278,000
80,000	8,300	6,000,000	332,800
90,000	9,000	7,000,000	388,100
100,000	9,700	8,000,000	444,000
200,000	16,400	9,000,000	500,400
300,000	22,600	10,000,000	557,300
400,000	28,600	11,000,000	614,700
500,000	34,400	12,000,000	672,500

$$*SE=e^{\frac{a}{2}+\frac{b}{2}[\ln(x)]^2}, where$$
$$a=9.93401$$
$$b=0.06362$$

TABLE D-2:

1990 VEHICLE ESTIMATES AND STANDARD ERRORS

Estimate (x)	One Standard Error (SE)*	Estimate (x)	One Standard Error (SE)*
1,000	400	600,000	39,900
5,000	1,000	700,000	46,100
10,000	1,600	800,000	52,200
20,000	2,500	900,000	58,400
30,000	3,400	1,000,000	64,700
40,000	4,200	2,000,000	128,300
50,000	4,900	3,000,000	194,500
60,000	5,700	4,000,000	263,100
70,000	6,400	5,000,000	334,000
80,000	7,100	6,000,000	406,900
90,000	7,800	7,000,000	481,600
100,000	8,500	8,000,000	558,200
200,000	15,000	9,000,000	636,400
300,000	21,300	10,000,000	716,100
400,000	27,500	11,000,000	797,400
500,000	33,700	12,000,000	880,100

$$*SE=e^{\frac{a}{2}+\frac{b}{2}[\ln(x)]^2}\text{, where}$$
$$a=8.83524$$
$$b=0.06977$$

TABLE D-3:

1990 PERSON ESTIMATES AND STANDARD ERRORS

Estimate (x)	One Standard Error (SE) *	Estimates	One Standard Error (SE) *
1,000	400	600,000	34,800
5,000	1,000	700,000	40,100
10,000	1,500	800,000	45,300
20,000	2,400	900,000	50,600
30,000	3,100	1,000,000	55,800
40,000	3,900	2,000,000	108,800
50,000	4,500	3,000,000	163,200
60,000	5,200	4,000,000	219,100
70,000	5,800	5,000,000	276,400
80,000	6,500	6,000,OOO	335,000
90,000	7,100	7,000,000	394,900
100,000	7,700	8,000,000	455,900
200,000	13,400	9,000,000	518,100
300,000	18,900	10,000,000	581,300
400,000	24,300	11,000,000	645,500
500,000	29,600	13000,000	710,600

APPENDIX E: REFERENCES

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